ANTIOXIDANT, COLOR AND SENSORY PROPERTIES OF SORGHUM BRAN IN PRE-COOKED GROUND BEEF PATTIES VARYING IN FAT AND IRON CONTENT

A Thesis

by

DAE KEUN SHIN

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

December 2006

Major Subject: Food Science and Technology

ANTIOXIDANT, COLOR AND SENSORY PROPERTIES OF SORGHUM BRAN IN PRE-COOKED GROUND BEEF PATTIES VARYING IN FAT AND IRON CONTENT

A Thesis

by

DAE KEUN SHIN

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

Approved by:

Co-Chairs of Committee,	Rhonda K. Miller
	Jimmy T. Keeton
Committee Members,	Stephen B. Smith
	Lloyd W. Rooney
Chair of Interdisciplinary Faculty,	Rhonda K. Miller

December 2006

Major Subject: Food Science and Technology

ABSTRACT

Antioxidant, Color and Sensory Properties of Sorghum Bran in Pre-Cooked Ground Beef Patties Varying in Fat and Iron Content. (December 2006)

Dae Keun Shin, B.S., Jeonbuk National University;

M.S., Seoul National University

Co-Chairs of Advisory Committee: Dr. Rhonda K. Miller
Dr. Jimmy T. Keeton

The effect of currently used antioxidants and sorghum bran in pre-cooked beef patties was evaluated at two different fat levels (10 and 27%, w/w). Pre-formulated ground beef was purchased at a retail store on three different processing days. Within each fat level, ground beef portions were weighed and randomly assigned to control, butylated hydroxanisole (BHA) and butylated hydroxytoluene (BHT) (0.001%), rosemary (0.25%) or sorghum bran (0.25, 0.5 or 1.0%). After mixing in the appropriate antioxidant, 200-g patties were formed, and pH and objective color measurements for each raw patty were performed. Patties were cooked to an internal temperature of 73^{o}C. Cooked patties were packaged and stored at 4^{o}C. Two patties per treatment were sampled after 0, 1, 3 and 5 d of storage and analyzed for 2-thiobarbituric acid reactive substances (TBARS), non-heme iron, pH, instrumental color and trained flavor and texture descriptive attributes.

The addition of BHA/BHT and rosemary extract to patties reduced non-heme iron, TBARS values, and cooked beef fat flavor attributes, but increased beef/brothy flavor attributes relative to control patties (P<0.05). As sorghum bran level increased, cooked beef patties were darker (P<0.05), less yellow (P<0.05), had higher non-heme iron

(P<0.05), lower TBARS (P<0.05) and higher sandy/gritty (P<0.05) sensory texture. Cooked patties containing antioxidants did not differ in other sensory attributes (P>0.05). Fat mouthfeel of control patties were higher than treated patties (P<0.05). Sorghum bran delayed lipid oxidation by reducing TBARS values and cooked beef fat flavors, and when used at 0.25 and 0.5%, minimal effects on color and sensory attributes were observed. Our results suggested that sorghum bran can be a desirable natural antioxidant in pre-cooked ground beef.

ACKNOWLEDGMENTS

I owe a debt to many people who helped me during my thesis project. First and foremost, I would like to thank my Lord who gives me an opportunity to study in the USA, and finally leads me to complete my thesis project without any hardship. Additionally, he also provides me with an incredible family: my parents, Won-Jib Shin and Youn-Hee Kim, have always loved me and made sacrifices for me to reach a goal at Texas A&M University. My sister, brother-in-law, niece and nephews, Sah-Im Shin, Han-Woo, Hae-Won, Si-Won and Ji-Won Kim, were always a source of strength and comfort to me.

I would also like to thank my committee co-chairs, Drs. Rhonda Miller and Jimmy Keeton. Their guidance and leadership during this project increased my enthusiasm and gave me the opportunity to gain the knowledge and experience necessary to accomplish my final goal. I am really honored to have them as my co-advisors. I am also indebted to Drs. Stephen Smith, Lloyd Rooney, Wes Osbourne and Ralph Waniska whose supervision helped to get this project done. Their great support and advice during this project has always encouraged me.

Finally, I am also graceful to my colleagues: Susan, Margaret, Betsy, Carlos, Diana, Brad, Kiyoung and Ryan. It has been a constant pleasure to work with them. Their friendship and aid made this project go smoothly. I also owe a gratitude to Jong-ho and Hyang-mi for their encouragement.

TABLE OF CONTENTS

CHAPTER Page

LIST OF TABLES

TABLE Page

TABLE Page

TABLE Page

LIST OF FIGURES

FIGURE Page

CHAPTER I

INTRODUCTION

Off-flavor development in pre-cooked and value-added beef products due to lipid oxidation is a major factor limiting beef shelf life. Lipid oxidation also has been associated with off-color development. To delay changes in quality and shelf-life, antioxidants are recommended as an effective defense against lipid oxidation. Many synthetic antioxidants, such as butylated hydroxanisole (BHA) and butylated hydroxytoluene (BHT), are used due to their convenience, low cost and antioxidant efficiency. However, due to chemical and toxicological risks, more health-conscious consumers are demanding the use of natural forms of antioxidants which are perceived safer than synthetic forms (Formanek et al., 2001). Many natural antioxidants have been used commercially including rosemary extract. The addition of rosemary extract reduces oxidative changes when it is added to ground pork before cooking (Guntensperger et al., 1998). Other natural antioxidants have been studied including the polymeric compounds of fruits, grains and vegetables (Kay and Holub, 2002; Kim et al., 2003; Mielnik et al., 2003; Mitsumoto et al., 2005). These compounds also have antioxidant properties and have been used as free radical scavenging and chelating agents in foods.

This thesis follows the style and format of the Journal of Animal Science.

Although many natural antioxidants act as either metal chelators or free radical scavengers, specific sorghum components have been shown to be effective antioxidants sufficient to replace synthetic antioxidants. Jenschke (2004) characterized the effectiveness of sorghum bran as an antioxidant in ground beef stored in a high oxygen environment. Sorghum bran contains various phytochemicals such as phenols and plicosanols (Awika et al., 2003a; Awika and Rooney, 2004) that provide a high oxygen radical absorbance capacity (ORAC), indicating high antioxidant properties (Awika et al., 2003b). Tannins, anthocyanins, other flavonoids and phenolic acids are available in sorghum, and provide strong antioxidant activity. The strength of such activity may depend on the polymer chain length and/or hydroxyl groups with a B-ring (Beninger and Hosfield, 2003; Awika and Rooney, 2004). Most of the antioxidant activity of tannins and anthocyanins are closely associated with water-based reactions. However, Hemphill (2006) noted that other compounds of sorghum bran could possibly prevent reactions of lipophilic components created during lipid oxidation.

Based on previous sorghum bran studies (Jenschke, 2004; Hemphill, 2006), we hypothesized that the phytochemical compounds of sorghum bran would reduce the metal ion activity and/or act as free radical scavengers when incorporated into beef patties. With less free iron, lipid oxidation and color stability would be enhanced, but this may depend on fat level and iron availability. The objective of this study was to determine an effective level of sorghum bran in pre-cooked, aerobically-stored ground beef patties containing two levels of fat. By altering fat levels, ground beef iron content should vary due to the inherent variation in raw materials used to formulate the ground

beef. A cooked ground beef model system was used to induce high levels of lipid oxidation and potentially induce increased levels of iron release. To test the antioxidant capacity of sorghum bran, three levels were added to beef patties. Thiobarbituric acid reactive substances (TBARS), non-heme iron content, pH, color stability and sensory characteristics of pre-cooked ground beef patties were performed. The results were compared to a control (no antioxidant added) patty and patties containing BHA/BHT and rosemary extract (a commonly used antioxidant in the meat industry).

CHAPTER II

LITERATURE REVIEW

Lipid oxidation is a major cause of deterioration in fresh and processed meat products and causes unacceptable flavor, color and texture. These undesirable qualities occur during oxidation and may be accelerated by free iron, unsaturated fats, cooking and other factors. Control of oxidation induced by iron and fat is important to extend shelf-life and increase meat quality. This review will address the major factors related to lipid oxidation and the use of sorghum bran as a natural antioxidant in pre-cooked ground beef patties.

Free Radical Formation

Free radicals are compounds that are very reactive and unstable, and serve as vital components in our immune system under normal biological conditions (Fang et al., 2002). Free radicals in foods are commonly formed by elevated temperature, photosensitizers, radiation and other factors such as heme or non-heme iron, and serve as initiators of lipid oxidation in muscle foods. The hydroxyl radical (OH•) is considered the major radical *in vivo*, and it has a high level of indiscriminate reactivity. Because of this indiscriminate reactivity, the hydroxyl radical is able to move from the site of origination to the cell membrane. This migration initiates lipid oxidation in the unsaturated fatty acid components of the cell membrane. The hydroxyl radical is short-lived and this process occurs rapidly (Minotti and Aust, 1987).

Many other free radicals such as superoxide ($O_2^{\bullet-}$), alkoxyl (RO•), alkyl (R•) and peroxyl (ROO•) radicals are common reaction products of active state dioxygen. Two basic theories describe the dioxygen state: the valence bond theory (O=O) and the molecular orbital theory (•O≡O•) (Miller et al., 1990). The molecular orbital theory provides a better explanation regarding the susceptibility of the dioxygen reaction with radical molecules because of two available radicals. Such a dioxygen may react with several biomolecules such as dopamine, cysteine and ascorbate to produce a superoxide or hydroperoxide by a one or two direct electron transfer. The activation of ground state dioxygen by both the electron reduction and spin conversion reactions would be required before oxidation.

$$RH_2 + O_2 \rightarrow RH + O_2^{\bullet-} + H^+ \text{ (one electron transfer)}$$

$$RH_2 + O_2 \rightarrow R + H_2O_2 \text{ (two electron transfer)}$$

Lipid Oxidation Reactions

Meat quality is a major concern in the meat industry, and lipid oxidation is one of the primary chemical mechanisms of quality deterioration in meat products. Lipid oxidation is the process by which molecular oxygen reacts with unsaturated lipids. Singlet oxygen, a very reactive and unstable molecule, attacks the double bond of an unsaturated fatty acid to form lipid peroxides. These peroxides cause a rapid deterioration of animal fat and can result in meat that has undesirable odors and colors that affect overall consumer acceptability. During the lipid oxidation process, three main steps occur: initiation, propagation and termination. Branching is another step that

can also occur. In the initiation step, the free radical (R•) is triggered by removing a hydrogen from an allylic methylene group of unsaturated lipid as a result of the interaction between the unsaturated lipid (RH) and an initiator (Angelo, 1996).

$$RH + initiator \rightarrow R\bullet$$

The formation of free radicals during the initiation step leads to the formation of peroxyl radicals. The peroxyl radical (ROO•) generates a hydroperoxide (ROOH) and a free radical as a result of the reaction between the peroxyl radical and the unsaturated fat molecule. The hydroperoxide may not respond directly to polyunsaturated fatty acids (Kanner, 1994). The branching step involves the hemolytic decomposition of hydroperoxide to form alkoxyl (RO•) and hydroxyl (OH•) radicals (Decker et al., 2000). An alkoxyl product with β-cleavage leads to oxidative and flavor deterioration of muscle foods by forming aldehydes and other products (Frankel and Meyer, 2000). The hydroperoxide has the potential to react with transition metals (Angelo, 1996) through the Fenton reaction (Minotti and Aust, 1987) and produce a free radical.

$$R\bullet + O_2 \rightarrow ROO\bullet$$

$$ROO\bullet + RH \rightarrow ROOH + R\bullet$$

$$ROOH \rightarrow RO\bullet + OH\bullet \text{ (branching)}$$

$$2ROOH \rightarrow ROO\bullet + RO\bullet + H_2O \text{ (branching)}$$

Termination is the final step involving a reaction of free radicals to form alcohols, aldehydes and hydrocarbons which are non-initiating and non-propagating products. Several mechanisms are suggested regarding these diverse oxygen conditions.

$$R\bullet + R\bullet \rightarrow RR \text{ (at low oxygen concentration)}$$

$$ROO\bullet + R\bullet \rightarrow ROOR \text{ (at medium oxygen concentration)}$$

$$ROO\bullet + ROO\bullet \rightarrow ROOR + O_2 \text{ (at high oxygen concentration)}$$

Iron as a Catalyst of Lipid Oxidation

Iron is an essential trace element in biology and plays a key role in various biological mechanisms. In live animals, iron levels are mostly maintained by absorption through intestinal mucosal cells. Most absorbed iron from the diet is bound to haemoglobin in red blood cells. The remainder of the iron is bound to myoglobin in skeletal muscle or bound to ferritin and/or haemosiderin in the liver (Chen et al., 1984; Decker and Welch, 1990; Lindley, 1996). Iron stored as haemoglobin in the live animal is the largest source of iron, but the iron contained in beef muscle is from a different source. The hemoglobin accounts for only 8-9% of the total pigments as compared to myoglobin (90-92%) in lean beef (Chen et al., 1984). This means that the iron bound to myoglobin is now a major factor affecting meat quality rather than the iron in haemoglobin.

Heme (Ryter and Tyrrell, 2000; Baron and Andersen, 2002) and non-heme iron (Lombardi-Boccia et al., 2002) act as catalysts to drive the production of free radicals in the initiation steps of lipid oxidation (Gutteridge and Halliwell, 1990). An iron-driven reaction usually involves the *d* orbital of iron, and it may ligate a dioxygen or biomolecule to speed up lipid oxidation (Kanner et al., 1988; Miller et al., 1990). The Harber-Weiss reaction depicts a sequence of reactions between superoxide or hydroperoxide radicals with iron in the ferrous or ferric state. A hydroxyl radical would

be produced as a final product through the Fenton reaction (Lukogorskaya et al., 2002) which depicts the actual oxidant by a one-electron reduction of H_2O_2.

$$Fe^{2+} + O_2 \rightarrow Fe^{3+} + O_2^{\bullet-}$$

$$2O_2^{\bullet-} + 2H^+ \rightarrow O_2 + H_2O_2$$

$$Fe^{2+} + H_2O_2 \rightarrow Fe^{3+} + OH\bullet + OH^-$$

Non-heme iron may not bind to the heme protein of myoglobin, but is found in ferritin, transferrin and haemosiderin (Lindely, 1996). The non-heme iron concentration in muscle foods may be influenced by storage time, temperature and pH. These factors accelerate protein denaturation by ionization. For example, Yasosky et al. (1984) theorized that the ionization of proximal histidine in myoglobin causes a change in the net charge and structural formation. This unexpected transition may reduce the affinity and release iron which can then bind to non-heme proteins. Hydrogen peroxide resides at low concentrations as a metabolite in mitochondrium, peroxisome, and microsome enzymes (Harel and Kanner, 1985). They are considered free radical generators when hydrogen peroxide combines with non-heme iron.

Cooking and reducing agents (Boyer and McCleary, 1987) may stimulate the release of iron from heme pigments. Schricker et al. (1982) proposed that an increase of non-heme iron content during cooking may be ascribed to the oxidative cleavage of the porphyrin ring. This allows the release of iron from the heme complexes. Increased non-heme iron is considered a major catalyst that accelerates lipid oxidation and then develops oxidized flavors in muscle foods. Non-heme iron, as compared to heme iron, easily extracts an electron from compounds and then forms free radicals.

Factors Affecting Lipid Oxidation

Pre-cooked beef patty quality is strongly influenced by lipid oxidation, which is affected by numerous factors such as cooking temperature, packaging condition and storage time. This section will address the major factors related to the lipid oxidation during cooking and storage.

Cooking Temperature: Heating is an important procedure to provide safe and convenient meat products. The quality of pre-cooked meat products is affected by lipid oxidation during heating. Pre-cooked meat products may oxidize quickly during cooking even though the Maillard reaction limits oxidation development in the pre-cooked products. Numerous Maillard reaction products formed during cooking may not sufficiently delay the oxidation of these products (Grun et al., 2006).

The cooking process stimulates the release of iron bound to heme pigments (Kristensen and Purslow, 2001). Due to the changes in muscle proteins during cooking, iron could be released from the heme complexes, and increase of this non-heme iron may be a major catalyst to accelerate lipid oxidation. In addition, most cook losses may be accelerated due to muscle protein denaturation during cooking (Seideman and Durland, 1984). Juices released during cooking may also carry non-heme iron. Cook loss of roasted beef is increased between 60 and 90^{o}C (Boles and Swan, 2002). Therefore, cooking above 70^{o}C may result in the release of higher levels of non-heme iron, and this could result in accelerated lipid oxidation.

Package Condition: Packaging conditions and the atmosphere surrounding a beef cut have been shown to affect rates of lipid oxidation. Proper packaging enhances the

storage stability of pre-cooked meat products. Modified atmosphere packaging (MAP) is used to maintain desirable color attributes whereas vacuum packaging (VP) is applied to extend the shelf-life of meat. The gas composition of most MAP is about 20-30% CO_2 and 70-80% O_2. Increased levels of CO_2 or O_2 suppress microbial growth or extend the color stability of meat (Jakobsen and Bertelsen, 2000). While O_2 increases the color stability of meat, the rate of lipid oxidation accelerates (Zhao et al., 1994). Therefore, at higher O_2 concentrations, rancidity also increases when compared to vacuum packaged products (Jackson et al., 1992; John et al., 2004).

Storage Time: Warmed over flavor (WOF) is closely related to oxidation enhancers and often considered synonymous with lipid oxidation development during storage. WOF, first characterized by Tims and Watts (Angelo and Bailey, 1987), has described the flavor deterioration associated with lipid oxidation in cooked meat. Rancid or stale flavors characteristic of WOF, arises within 48 hrs in cooked meats storaged at 4^oC (Tims and Watts, 1958; Angelo and Bailey, 1987). Rancidity in raw meat requires several days under the same storage conditions. Therefore, storage time is closely related to the lipid oxidation of pre-cooked meat products.

Extended storage periods may influence the solubility of oxygen in water. Increased oxygen solubility affects lipid oxidation. Dissolved oxygen produces hydrogen peroxide (H_2O_2) which can cross cell membranes (Gulcin et al., 2003), and disrupts the porphyrin structure of myoglobin, which in turn releases iron (Kanner, 1994). At the same time through a potential reaction with free irons (the Fenton reaction), H_2O_2 also produces hydroxyl radicals (OH•) (Minotti and Aust, 1987).

Therefore, storage time could be the most important factor in reducing lipid oxidation (Jakobsen and Bertelsen, 2000).

Antioxidant Reactions

To delay the start or slow the rate of lipid oxidation, an antioxidant is often added to meat products. Antioxidants have been defined as 'substances that in small quantities are able to prevent or greatly retard the oxidation of easily oxidizable materials such as fats (Frankel and Meyer, 2000). Antioxidants play a key role in the initiation or propagation step of lipid oxidation. Various preconditions are required for an antioxidant to be effective in beef. To be a successful free radical scavenger or metal chelator, an antioxidant must have either a hydroxyl group in the carbon three position, a double bond between carbon positions two and three, a carbonyl group in carbon position four and/or a polyhydroxylation of the A and B aromatic (Cook and Samman, 1996). Under oxidative conditions, antioxidants react with free radicals as an electron donor, acceptor or terminator. The following reactions schematically describe the reaction between an antioxidant and free radicals:

(Antioxidant as a donor under unlimited oxygen condition)

$$ROO\bullet + AH \rightarrow ROOH + A\bullet$$

(Antioxidant as a donor under limited oxygen condition)

$$R\bullet + AH \rightarrow RH + A\bullet$$

(Antioxidant as an acceptor; R*= a lipid with a new double bond)

$$R\bullet + A\bullet \rightarrow RA \rightarrow R^* + AH$$

(Antioxidant as a terminator)

$$RO\bullet + AH \rightarrow ROH + A\bullet$$

$$RO\bullet + A\bullet \rightarrow ROA$$

The transition metal, which exists in a diverse spin state, may possibly inhibit the reaction with a superoxide and hydroperoxide by chelating the metal. Since the metal chelator forms a complex with transition metals, transition metals may not produce hydroxyl radicals through the iron-catalysed Haber-Weiss reaction (Gutteridge et al., 1979). Metal chelation demands that there be two or more atoms that can bind transition metals on the same molecules. For example, the ortho-dihydroxyl group of a flavonoid with a B-ring chelates transition metals due to a complex with transition metals (Hemingway and Laks, 1992).

Antioxidant Activities of BHA/BHT and Rosemary Extract

BHA/BHT: Butylated hydroxyanisole (BHA) and butylated hydroxytoluene (BHT) are synthetic phenolic compounds which are commonly added to meat and poultry products. BHA and BHT are considered to be free radical terminators and commonly used in meat products such as fresh breakfast sausage and dried products (Sebranek et al., 2005). Due to their lower cost and higher antioxidant activities at very low levels, most meat processors use BHA and BHT to extend shelf-life by reducing oxidative changes in restructured beef products and cooked pork (Tang et al., 2001).

USDA regulations allow the use of BHA and BHT up to 0.01% (based on fat content) in fresh sausage and up to 0.003% (based on total weight) in dry sausage

(Ladikos and Lougovois, 1990; Sebranek et al., 2005). Ahn et al. (2002) reported that a 1:1 mixture of 0.01% (w/w) BHA and 0.01% (w/w) BHT was effective in increasing the oxidative stabilities of cooked ground beef when compared to ground beef containing 0.02% rosemary. In addition, BHA provided oxidative stabilities during cooking, storage and reheating when it was injected into ducks in a combination with α-tocopherol (Ladikos and Lougovois, 1990).

Rosemary Extract: Rosemary extract, a strong natural antioxidant, is derived from the leaves of rosemary. Rosemary extract contains several phenolic antioxidant compounds. Normally, phenolic compounds react with lipid or hydroxyl radicals to make them stable (Formanek et al., 2001). Butler and Larick (1993) observed that rosemary oleoresion reduced the oxidative changes and improved sensory characteristics of aseptically processed low-fat beef gels. In addition, Hemphill (2006) reported that the addition of rosemary to beef patties lowered TBARS values when compared to control patties during refrigerated storage.

The addition of rosemary extract was a more effective antioxidant when added to ground pork immediately after cooking (Guntensperger et al., 1998). Guntensperger et al. (1998) also reported that the addition of rosemary extract to pre-cooked meats resulted in oxidatively stabilized products when packaged with nitrogen flushing. Moreover, Murphy et al. (1998) found that antioxidant properties of rosemary in sausage may be due to various isoprenoid quinines, which terminated and/or quenched the free radicals and/or reactive oxygen species.

Antioxidant Activities of Sorghum

Sorghum bran contains high levels of phenols, policosanols and sterols. The phenolic compounds serve as defenses for the sorghum against pests and diseases (Awika and Rooney, 2004). Although various phytochemicals in sorghum are available depending on species, phenolic acids and flavonoids are the most abundant. These phenolic acids and flavonoids are considered to be the major compounds acting as antioxidants. Tannins are polymeric compounds formed from flavonoids during the break down of tissues (Kumar and Sinha, 2004). Tannins vary in molecular weight (500-5000MW) (Brune et al., 1989) and are divided into two groups: condensed and hydrolysable tannins. Condensed tannins are large polymers present in some sorghums. They form an insoluble complex with proteins and carbohydrates (Awika et al., 2003a).

Anthocyanins are widely distributed in plants, fruits and vegetables. Anthocyanins are responsible for the pink, red, purple and blue colors of plants, fruits and vegetables depending on pH, temperature, oxygen and metallic ions (Ahmed et al., 2004). Most anthocyanins have hydroxyl groups on the C-1 and C-3 positions. However, the 3-deoxyanthocyanidins, apigeninidin or luteolinidin, are the most common anthocyanins in sorghum. A unique characteristic of 3-deoxyanthocyanidins is their stability in acidic solutions, as opposed to other anthocyanins which are not acid stable. Due to a characteristic of 3-deoxyanthocyanidins, anthocyanins of sorghum bran may be stable in the pH range of most fresh meats and therefore, easily maintain their antioxidant properties. Sorghum bran provides higher levels of anthocyanins than whole grains. Moreover, anthocyanins are more abundant in black sorghum than other

sorghums (Awika, 2000). Awika et al. (2004) reported that anthocyanins extracted from black sorghum had antioxidant activities similar to fruits and vegetables.

Effect of Sorghum in Pre-Cooked Meat Quality

The cooking process and storage environment result in chemical reactions that change the color, flavor and texture of beef patties. One of the main chemical reactions is lipid oxidation. However, the phenols of sorghum bran may delay these lipid oxidation reactions. Low molecular weight phenols chelate iron at pH values of 5.8 and 7.4 (Hagerman et al., 1998), which is in the pH range of raw beef patties with sorghum bran (6.35-6.41) (Hemphill, 2006). The pigment structure of meat is directly associated with pH. Likewise, meat color and pigment stabilization with anthocyanins and tannins of sorghum bran are also dependent on pH (Jenschke, 2004; Hemphill, 2006).

Some anthocyanins in sorghum may affect meat color by the presence of a hydroxyl group at the C-3 position, although 3-deoxyanthocyanidins are the most common in sorghum. A hydroxyl group at the C-3 position of anthocyanin shifts the color from yellow-orange to red (Ahmed et al., 2004). The complex reactions of pH and sorghum bran have been shown to increase color stability and provide darker, but less red and yellow, ground beef color (Jenschke, 2004; Hemphill, 2006).

Anthocynins are sensitive to heat processing. Thermal processes create a loss in desirable color (Suh et al., 2004) and heme iron content (Lombardi-Boccia et al., 2002) as the pigment degrades. Due to thermal processing, the browning index of anthocyanins is increased with pH (Suh et al., 2004) and the incidence of premature

browning can be increased depending on packaging conditions (Mancini and Hunt, 2005). Ahmed et al. (2004) reported that Hunter L*, a* and b* values of anthocyanins were reduced with increased heating time and temperature.

WOF associated with lipid oxidation is commonly recognized as cardboardy, painty and musty-like flavors. Previous studies (Jenschke, 2004; Hemphill, 2006) have shown the addition of sorghum bran reduced cooked beefy/brothy and serumy flavors with no cardboardy- or painty-like flavors detected during refrigerated storage. Moreover, no significant differences were observed in astringency, one of the important tannin tastes (Kumar and Sinha, 2004), but the addition of sorghum bran increased a sandy/gritty texture in ground beef patties.

CHAPTER III

MATERIALS AND METHODS

Sample Preparation

Ground beef with fat contents of 10 and 27% (w/w) were purchased from a retail store on three separate processing days (processing day was defined as a replicate). The fat and moisture contents of each ground beef fat treatment were verified using the CEM auto-analyzer (Smart Trac System, CEM Co. Matthews, NC). Within a treatment and fat level, ground beef was weighed and the appropriate antioxidant ingredient added: i) control-no ingredient added; ii) both 0.01% butylated hydroxyanisole (BHA) and butylated hydroxytoluene (BHT) (TENOX®, Eastman Chemical Products, Kingsport, TN); iii) 0.25% rosemary (Herbalox® Type HT 25, Kalsec Inc., Kalamanzo, MI) in oil; iv) 0.25% sorghum bran; v) 0.5% sorghum bran; and vi) 1% sorghum bran. These sorghum levels were predetermined in a preliminary study. A sumac bran sorghum cultivated in College Station was harvested and dehulled using a PRL dehuller (Nutama Machine Co., Saskatoon, Canada). A pin mill was used to reduce the bran particle size to pass through a 40 and above mesh. Both the control and meat antioxidant treatment were mixed in a paddle mixer (Hobart Co., Troy, OH) for 2 min to distribute the antioxidant throughout the ground beef matrix.

Patties (200 g) were formed using a standard patty mold (Tupperware^{TM} Hamburger Press), and pH and objective color evaluations were determined. After instrumental analysis, all raw patties were pre-cooked at 180^{o}C in a convection oven (HOBART, Hobart Co., Troy, OH). Internal temperatures were monitored by a copper-

constantan thermocouple (Omega Engineering, Stamford, CT) inserted into the geometric center of each patty. When patties had reached an internal temperature of 73°C, they were removed and cooled at 4°C for 30 min. After cooling, two patties were packaged (Heat Sealing Equip. Co., Cleveland 14, OH) on a foam tray (CRYOVAC®, Sealed Air Co., Saddle Brook, NJ) with PVC film (Stretchable Meat Film 55003815; Prime Source, St. Louis, MO) for instrumental and sensory evaluations. Two packages within a treatment were randomly assigned to storage day (0, 1, 3 and 5 d) and stored at 4°C in a cardboard box. Within a storage day and treatment, four patties were used for instrumental and sensory testing. Two patties per treatment were used to determine pH values, thiobarbituric acid reactive substances (TBARS) and objective color evaluation on d 0, 1, 3 and 5 of storage. The non-heme iron content was measured on d 0 and 5, and two patties per treatment were used for trained descriptive attribute sensory evaluations on storage d 1 and 5.

Instrumental Measurements

Objective color was measured using a colorimeter (Minolta Chroma Meter CR-300; Minolta Co., Ltd., Ramsey, NJ) whose port was covered with PVC film and calibrated daily using a white tile (Y = 94.3, x = 0.3130 and y = 0.3199). Three different readings were randomly obtained from the exterior surface of each patty. Average CIE L*, a* and b* color space values (lightness, redness and yellowness, respectively) were reported.

The ultimate pH of the patty was measured with a pH meter (HI 98240, Hanna Inc., Italy) by placing the probe into the center of each patty at three random locations, and reading the pH obtained after the values stabilized. The average value of the three pH readings was reported. The pH meter was calibrated with standard buffers at pH 4.0 and 7.0 daily.

Cook loss was expressed as a percentage of raw beef patty weight by weighing each patty before and after cooking.

$$\text{Cook loss (\%)} = [1 - (\text{weight of cooked patty/weight of raw patty})] \times 100$$

For non-heme iron content, two 5-g samples were taken from a beef patty after homogenization in a food processor (Waring® Commercial Blender, New Hartford, Connecticut). Sodium nitrite (NaNO) regent (0.2 mL of 0.39% $NaNO_2$) and 15 mL of 6N HCl with 40% trichloroacetic acid were then combined with the 5-g sample in a test tube. Tubes were incubated in a water bath-shaker (Water Bath Shaker, American Optical, Buffalo, NY) at 65^{o}C for 20 h. After incubation, 1 mL of the liquid phase was removed and mixed with 5 mL of water:saturated sodium acetate solution (21:20, vol:vol). For the second phase, 1 mL of the acidic liquid was removed and mixed with 5 mL of a color reagent (deionized water:saturated sodium acetate solution:bathophenanthroline disulfonate reagent, 20:20:1, vol:vol:vol). The bathophenanthroline disulfonate reagent was made with 0.162 g of bathophenanthroline disulfonic acid and 2 mL of thioglycolic acid in 100 mL deionized water. Each mixture was centrifuged (Beckman-Coulter, Avanti J-25; Palo Alto, CA) at 3,500 × g for 10 min. The sample from the first step was read at 540 nm against a blank. The blank was a

mixture of 1 mL of acid mixture and 5 mL of deionized water:saturated sodium acetate solution (21:20, vol:vol). Samples from phase 2 were removed and read at 540 nm against a blank (1 mL of acid mixture with 5 mL of color reagent). The liquid phase blank was subtracted from each sample value, and the iron content was confirmed using a ferrous (Fe^{2+}) standard curve (0-15.0 μg Fe/mL). The amount of non-heme iron content of the meat was determined and calculated using a procedure described by Schricker et al. (1982) as modified by Rhee and Ziprin (1987).

μg non-heme iron/g meat = Fe concentration of the incubated liquid phase (μg/mL)

$\times$ (15 + 0.2 + moisture content of 5 g meat)(mL)/5 g

The TBARS values were tested to determine the degree of lipid oxidation using the method of Tarladgis et al. (1960) as modified by Rhee (1978). Two 30-g samples were removed from each patty and blended (Waring® commercial blender, New Hartford, Connecticut) with 45 mL of 50°C deionized water and 15 mL of a 0.5% solution of propyl gallate (PG) and ethylenediamine tetraacetic acid (EDTA) for 2 min. Thirty grams of slurry were transferred into a 500-mL Kjeldahl flask and rinsed with 77.5 mL of 50°C deionized water. Slipicone® (Dow Corning®, Midland, MI) was sprayed to reduce unexpected foaming during boiling as well as 5-6 boiling chips, and 2.5 mL of 4N HCl was added to each flask. Kjeldahl flasks were set on a distillation unit and removed when 50 mL of each sample was collected. Five milliliters of the sample distillate and 5 mL of 0.02M TBA reagent were added and mixed in a screw cap test tube. These mixtures and blank (5 mL distilled water with 5 mL TBA reagent) were heated in boiling water for 35 min and cooled to room temperature for 10 min. After

cooling, a blank was placed in a cuvette (VWR, West Chester, PA) and read at 530 nm using a UV-spectrophotometer (Genesys 10uv, Thermo Spectronic, Rochester, NY). The reading value of the blank was set as 0 absorbance and then the remaining samples measured and calculated as follows;

TBARS value = Abs 530 nm × 7.8 (conversion factor) mg malonaldehyde/kg sample

Each value was expressed as mg malonaldehyde/kg of ground beef.

Sensory Measurements

For sensory evaluation, two patties from each treatment were re-heated in a 1.53-kw microwave (Household Microwave Oven, VAC/HZ 120/60, General Electric Co., Louisvile, KY) for 1.5 min. After re-heating, each patty was cut into 2.0 cm^3 cubes and served to panelists. Six sensory panelists were selected and trained according to AMSA (1995) and Meilgaard et al. (1999) procedures. The varied flavor and texture characteristics were evaluated with a ballot developed by Jenschke, (2004). Ballot development sessions had been conducted prior to the initiation of the study to assure that flavor and texture attributes in the patties were included on the ballot. Specific flavor characters, such as cooked beef/brothy, cooked beef fat, grainy, cardboard, musty, burnt and sorghum flavor aromatic attributes; salt, sour and bitter basic taste attributes; sour, bitter, burnt and musty after-taste attributes; metallic and astringent flavor feeling factors; and, metallic, astringent, fat mouthfeel and sorghum mouthfeel flavor after-feeling factors were described with the Spectrum Universal scale where 0 = none and 15 = extremely intense. The Spectrum Universal scale was also used to describe the

springiness (0 = not springy and 15 = very springy), hardness (0 = very soft and 15 = very hard), sandy/gritty (0 = none and 15 = very sandy/gritty) and juiciness (0 = none and 15 = very juicy) texture attributes.

Each trained panelist was randomly provided two pieces of each sample, and samples were identified using 3-digit random codes. Panelists were seated individually in sensory booths under red theater gel lights to reduce collaboration between panelists. The sensory panel room was maintained at 23^{o}C and 55% relative humidity. Unsalted saltine crackers and room temperature double distilled deionized water were served to panelists between samples. Panelists were given a 3 min interval between samples to remove any residual flavors from previous samples. Two sessions were conducted with six treatment samples served during a session with a 15 min break between sessions.

Statistical Analysis

Data were analyzed as a factorial arrangement by Analysis of Variance using the generalized linear model (GLM) procedure of SAS (Version 6.12, Cary, NC, 1998) with a predetermined significance level of $P < 0.05$. For chemical data, main effects of treatment, fat level and storage day and two- and three-way interactions were included in the initial model with processing day as a block. Two- and three-way interactions for all main effects were analyzed and remained in the final model if they were significant ($P < 0.05$). Least squares means were estimated and separated using the stderr pdiff function if differences were determined by Analysis of Variance. All final models included main effects and significant ($P < 0.05$) two- and three-way interactions. For analysis of

variance of independent variables of TBARS and non-heme iron, cook time and cook loss were used as a covariate to understand if differences in cooking parameters influenced TBARS and non-heme iron content. Additionally, for TBARS analysis, non-heme iron was included in a model to understand if non-heme iron content affected TBARS values in pre-cooked beef patties. The covariate analysis was also conducted where cook time was used as a covariate in the model for cook loss, and reported if cook loss was influenced significantly ($P < 0.05$). For sensory data, the data were examined to evaluate the effect of panel and panel interactions with main effects as described in the previous model. The data were analyzed as defined for the chemical data if panel interactions were not significant ($P \geq 0.05$).

CHAPTER IV

RESULTS AND DISCUSSION

Chemical Characteristics of Raw Beef Patties

Least squares mean for replication treatment and fat level for chemical characteristics of raw ground beef are presented in Tables 1 and 2. Ground beef patties in replication 3 were lower in fat, pH, CIE L*, a* and b* color space values and higher in moisture than ground beef patties from replications 1 and 2. Ground beef was purchased separately for each replicate, which caused the chemical measures to differ among replicates. Replication by fat level interactions were reported for fat and moisture percentage, CIE L*, a* and b* color space values (P = 0.0065 and 0.0105 and P = 0.0001, 0.0032 and 0.0477, respectively) (Figs. 1 and 2). Ground beef patties from the 10 % fat treatment in replicate 3 were lower in fat content, higher in moisture content and had lower CIE L*, a* and b* values than 10% fat ground beef patties in replicates 1 and 2. For ground beef patties from the 27% fat treatment, ground beef patties from replicate 2 had a lower moisture content and CIE a* color space values and higher fat and CIE L* color space values. These differences in chemical attributes of raw ground beef across replicates likely were due to random variation in raw materials.

Raw ground beef patties across antioxidant treatments did not differ in pH (P = 0.88) or non-heme iron content (P = 0.12) (Table 1). However, raw ground beef patties containing medium and high levels of sorghum bran were darker with lower levels of red and yellow than control and patties from the other treatments. Hemphill (2006) reported that raw ground beef patties had darker and less red and yellow color space values when

1% sorghum bran was added to the patties. Our CIE L*, a* and b* color space values indicate that sorghum bran addition at 0.5 and 1% of the raw weight of ground beef patties altered the color of patties.

Ground beef patties from the 27% fat treatment were fatter, had lower moisture content, higher pH, and were darker with higher levels of red and yellow than 10% fat patties (Tables 1 and 2). Non-heme iron did not differ between ground beef patties differing in fat treatment. By design, these patties differed in fat content. There was a significant fat level by treatment interaction for CIE a* and b* color space values (Fig. 3). Ground beef patties from the 10% fat treatment did not differ appreciably in a* and b* color space values across treatments. However, sorghum bran addition to 27% fat ground beef patties had depressed red and yellow values. As ground beef patties containing 27% fat would have a higher proportion of light particles from fat, sorghum bran would be more visible and most likely affected color.

These results indicate that ground beef patties differed in chemical and color attributes due to replication, treatment and fat content. Hemphill (2006) packaged raw ground beef patties on a styraform tray with PVC film and stored them for 6 d. Replication, treatment, fat level, and storage day affected pH and L*, a* and b* color space values of raw ground beef patties. Therefore, the fat content differences would depend on the raw material used for manufacturing of the ground beef patties, and differences due to treatment were mainly associated with addition of medium and high sorghum bran.

Table 1. Main effect least squares means for fat, moisture, pH and non-heme iron content of raw beef patties.

Effect	Fat %	Moisture %	pH	Non-heme iron (μg/g)
Replication				
P-value	0.0001	0.0001	0.0001	0.2170
1	15.93[d]	65.04[d]	6.16[d]	4.27
2	17.08[e]	64.17[c]	6.27[d]	3.19
3	13.75[c]	67.02[e]	5.89[c]	4.91
Treatment[a]				
P-value	-	-	0.88	0.1285
Control	-	-	6.14	2.78
BHA/BHT	-	-	6.07	3.78
Rosemary	-	-	6.06	3.44
Low sorghum	-	-	6.11	4.14
Medium sorghum	-	-	6.11	3.93
High sorghum	-	-	6.02	6.66
Fat %				
P-value	0.0001	0.0001	0.0023	0.1613
10	7.40[c]	71.86[d]	6.02[c]	4.69
27	23.77[d]	58.96[c]	6.19[d]	3.55
Root MSE[b]	0.420	0.334	0.146	2.370

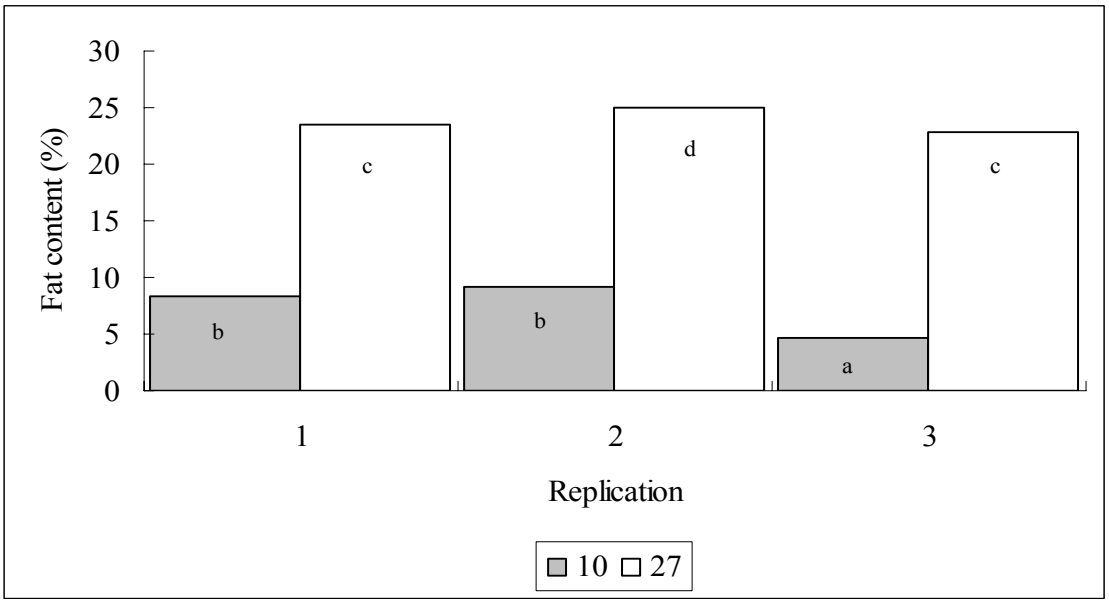
[a] Treatments: Control = no antioxidant; BHA/BHT = 0.01% respectively; Rosemary = 0.25%; Low sorghum bran = 0.25%; Medium sorghum bran = 0.5%; High sorghum bran = 1.0% (w/w).
[b] Root Mean Square Error.
[c-e] Mean values within a column and main effect followed by the same letter are not significantly different ($P > 0.05$).

Table 2. Main effect least squares means for CIE L*, a* and b* of raw beef patties.

Effect	CIE Color Space Values[c]		
	L*	a*	b*
Replication			
P-value	0.0022	0.0206	0.0003
1	53.05[e]	19.99[e]	11.46[e]
2	53.04[e]	19.48[de]	11.44[e]
3	51.81[d]	19.00[d]	10.63[d]
Treatment[a]			
P-value	0.0001	0.0001	0.0054
Control	53.32[f]	20.54[g]	11.48[e]
BHA/BHT	53.75[f]	20.31[fg]	11.26[e]
Rosemary	53.99[f]	20.62[g]	11.62[f]
Low sorghum	53.39[f]	19.45[ef]	11.23[e]
Medium sorghum	51.31[e]	18.80[e]	10.98[de]
High sorghum	50.06[d]	17.23[d]	10.47[d]
Fat %			
P-value	0.0001	0.0001	0.0001
10	49.53[d]	16.12[d]	9.51[d]
27	55.74[e]	22.86[e]	12.84[e]
Root MSE[b]	0.873	0.791	0.463

[a] Treatments: Control = no antioxidant; BHA/BHT = 0.01% respectively; Rosemary = 0.25%; Low sorghum bran = 0.25%; Medium sorghum bran = 0.5%; High sorghum bran = 1.0% (w/w).
[b] Root Mean Square Error.
[c] CIE color space values: L* = lightness; a* = redness; b* = yellowness.
[d-g] Mean values within a column and main effect followed by the same letter are not significantly different ($P > 0.05$).

(a) $P = 0.0065$



(b) $P = 0.0105$

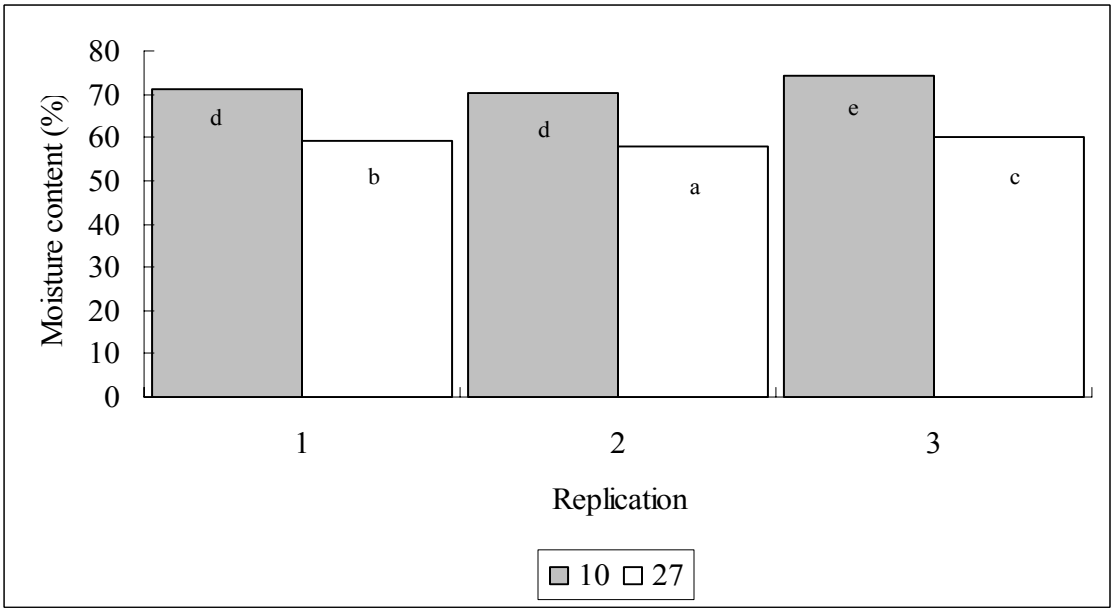
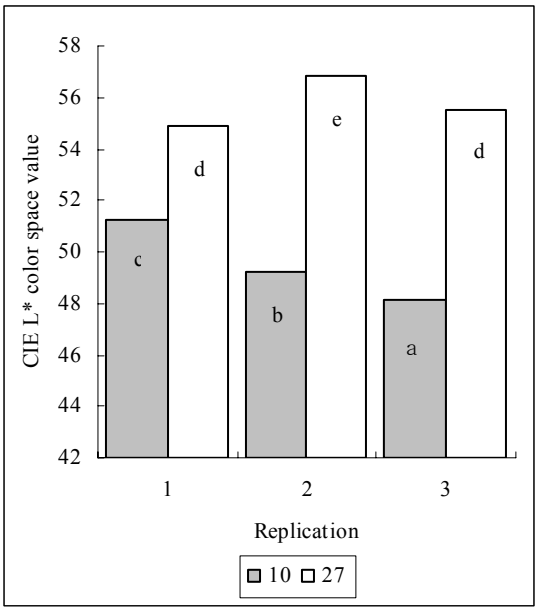


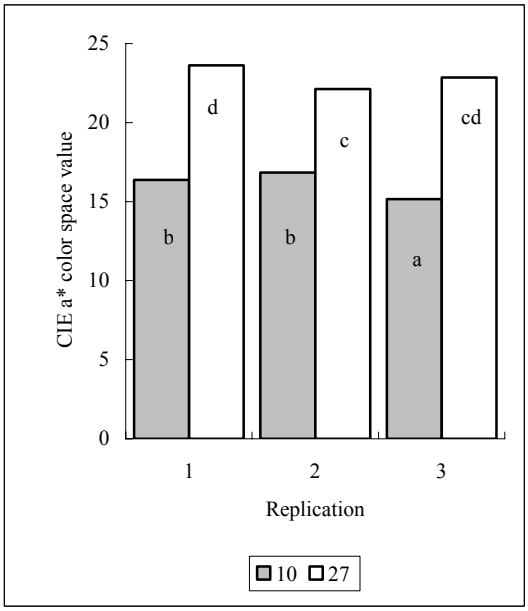
Fig. 1. Least squares means for replication by fat level interaction for fat and moisture contents of raw ground beef.

[a-e] Mean values followed by the same letter are not significantly different ($P > 0.05$).

(a) $P = 0.0001$



(b) $P = 0.0032$



(c) $P = 0.0477$

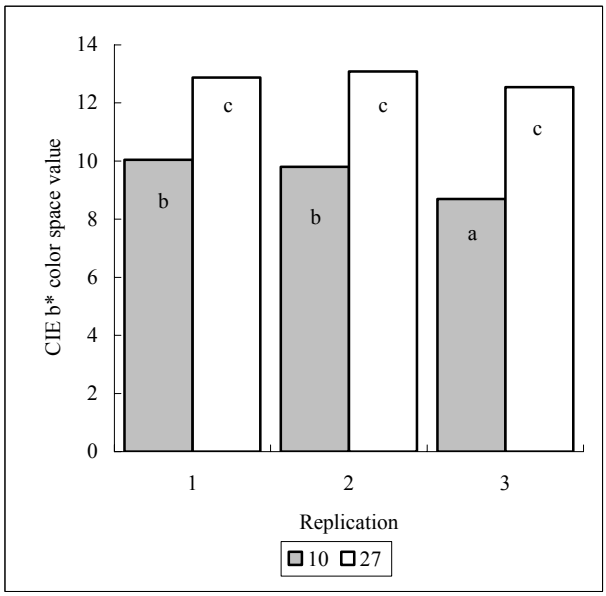
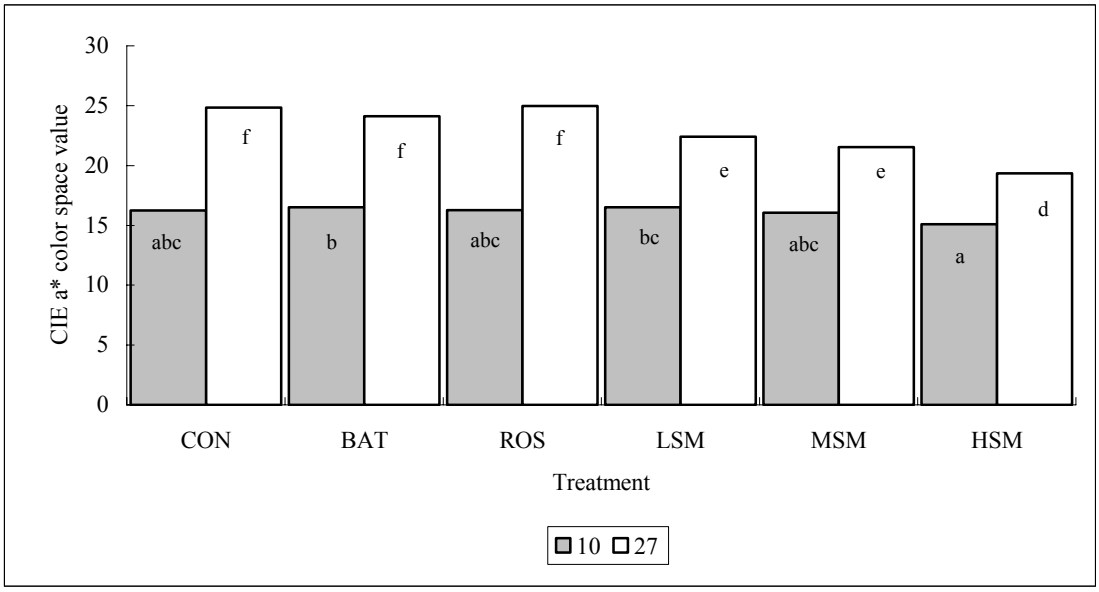


Fig. 2. Least squares means for replication by fat level interaction for CIE L*(a), a*(b) and b*(c) color space values of raw beef patties.

CIE color space values: L* = lightness; a* = redness; b* = yellowness.
[a-e] Mean values followed by the same letter are not significantly different ($P > 0.05$).

(a) $P = 0.0003$



(b) $P = 0.0046$

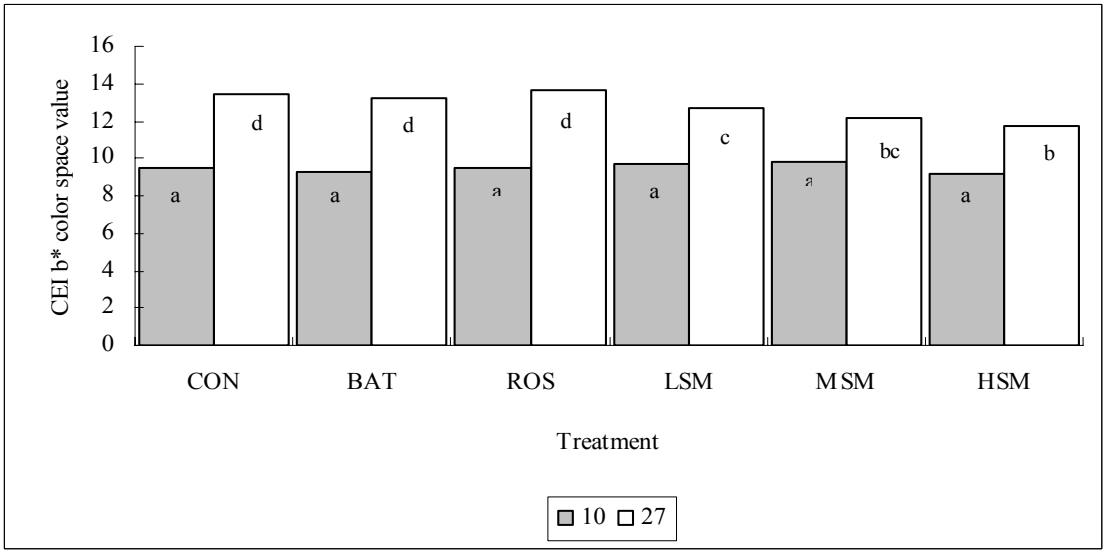


Fig. 3. Least squares means for fat level by treatment interaction for CIE a*(a) and b*(b) color space values of raw beef patties.

Treatments: CON = Control (no antioxidant); BAT = BHA/BHT (0.01% respectively); ROS = Rosemary (0.25%); LSM = Low sorghum bran (0.25%); MSM = Medium sorghum bran (0.5%); HSM = High sorghum bran (1.0%) (w/w). CIE color space values: a* = redness; b* = yellowness.

[a-f] Mean values followed by the same letter are not significantly different ($P > 0.05$).

Final Endpoint Temperature, Cook Time and Cook Loss of Pre-Cooked Beef Patties

Final endpoint temperature (^{o}C), cook time (min) and cook loss (%) were measured to determine if treatments would influence these attributes (Table 3). Patties were cooked to an internal temperature of 73^{o}C. Internal temperature endpoint, length of cooking and cook loss have been shown to effect ground beef patty sensory and chemical attributes (Brewer and Novakofski, 1999; Boles and Swan, 2002).

Main effects of replication, treatment and storage day were significant ($P < 0.05$) for internal cook temperature, and the interaction for this attribute with replicate and treatment was significant as well (Figs. 4 and 5). Cook time was affected by replication, treatment and fat level, whereas cook loss was affected by treatment, fat level, and there was a significant replication by fat level interaction (Fig. 6). Internal cook temperature differences were most likely due to human error, density of the patty and placement of the thermocouple and not due to treatment effects. Patties from replicate 1 with 10% fat had higher cook temperature endpoints and 10% high sorghum bran patties had lower cook temperature endpoints than patties from other treatments. Although care was taken to properly monitor cooking endpoint temperatures, these effects occurred. The major impact of these effects most likely resulted in shorter cook time for high sorghum bran patties that then resulted in lower cook loss.

Table 3. Main effect least squares means for internal cook temperature, cook time and cook loss of beef patties.

Effect	Internal Cook Temperature (^{o}C)	Cook Time (min)	Cook Loss %
Replication			
P-values	0.0108	0.0207	0.2292
1	73.74^{d}	14.98^{c}	29.28
2	73.18^{c}	14.81^{c}	29.78
3	73.48^{cd}	15.73^{d}	30.24
Treatment[a]			
P-values	0.0103	0.01	0.0017
Control	73.51^{d}	14.21^{c}	29.07^{de}
BHA/BHT	73.72^{d}	14.88^{cd}	30.87^{d}
Rosemary	73.68^{d}	15.73^{d}	30.59^{de}
Low sorghum	73.60^{d}	15.58^{d}	30.07^{de}
Medium sorghum	73.44^{d}	15.77^{d}	30.21^{de}
High sorghum	72.84^{c}	14.90^{cd}	27.81^{c}
Storage day			
P-values	0.0156	0.9719	0.084
0	73.19^{c}	15.11	29.18
1	73.27^{cd}	15.13	29.30
3	73.63^{de}	15.29	29.89
5	73.78^{e}	15.16	30.70
Fat %			
P-values	0.1144	0.0001	0.0001
10	73.58	13.91^{c}	22.32^{c}
27	73.35	16.44^{d}	37.22^{d}
Root MSE[b]	0.894	1.713	2.722

[a] Treatments: Control = no antioxidant; BHA/BHT = 0.01% respectively; Rosemary = 0.25%; Low sorghum bran = 0.25%; Medium sorghum bran = 0.5%; High sorghum bran = 1.0% (w/w).
[b] Root Mean Square Error.
[c-e] Mean values within a column and main effect followed by the same letter are not significantly different ($P > 0.05$).

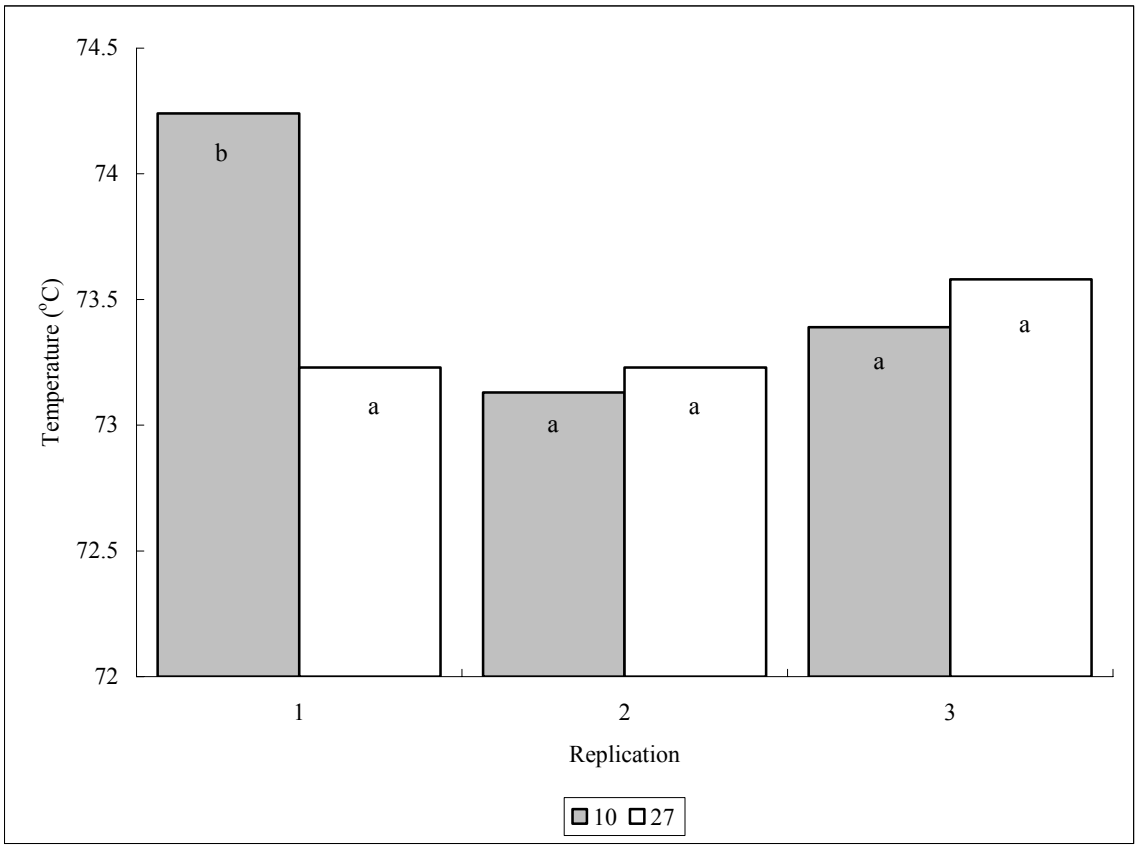


Fig. 4. Least squares means for fat level by replication interaction for cook temperature of cooked beef patties ($P = 0.0016$).

[ab] Mean values followed by the same letter are not significantly different ($P > 0.05$).

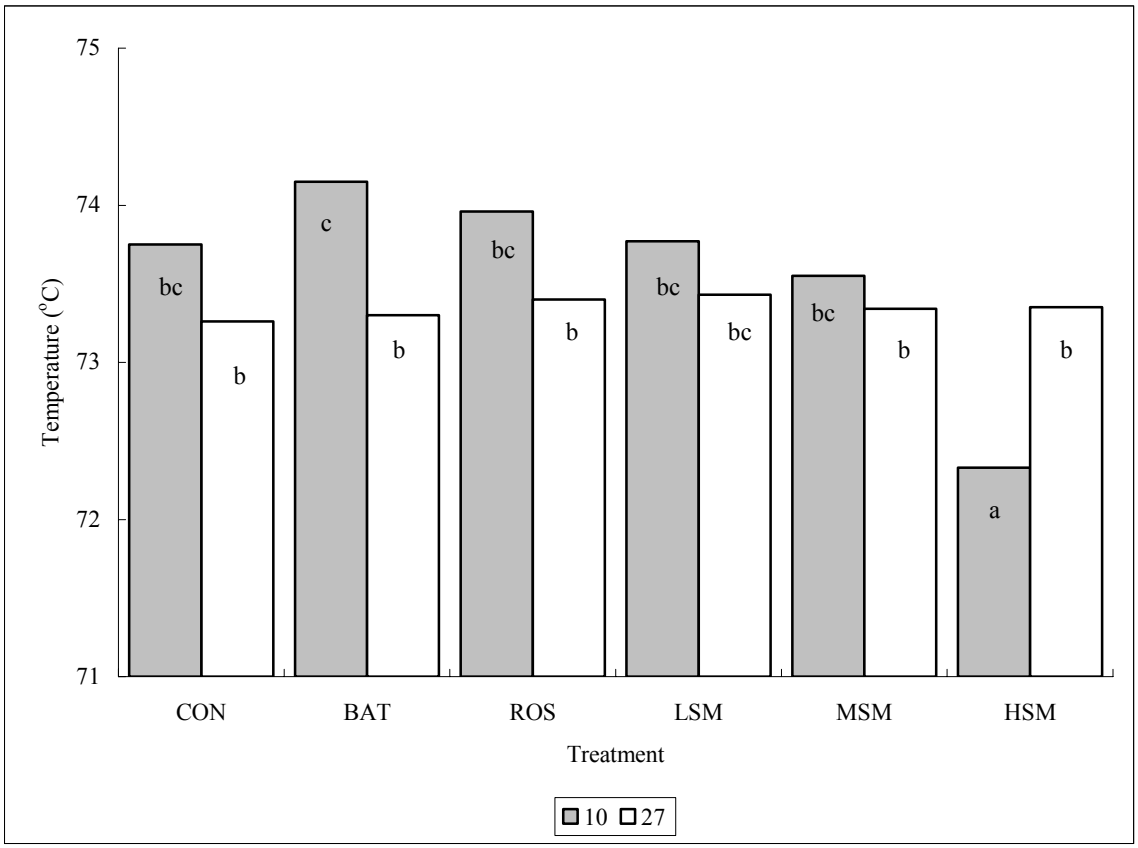


Fig. 5. Least squares means for fat level by treatment interaction for cook temperature of cooked beef patties ($P = 0.0087$).

Treatments: CON = Control (no antioxidant); BAT = BHA/BHT (0.01% respectively); ROS = Rosemary (0.25%); LSM = Low sorghum bran (0.25%); MSM = Medium sorghum bran (0.5%); HSM = High sorghum bran (1.0%) (w/w). [a-c] Mean values followed by the same letter are not significantly different ($P > 0.05$).

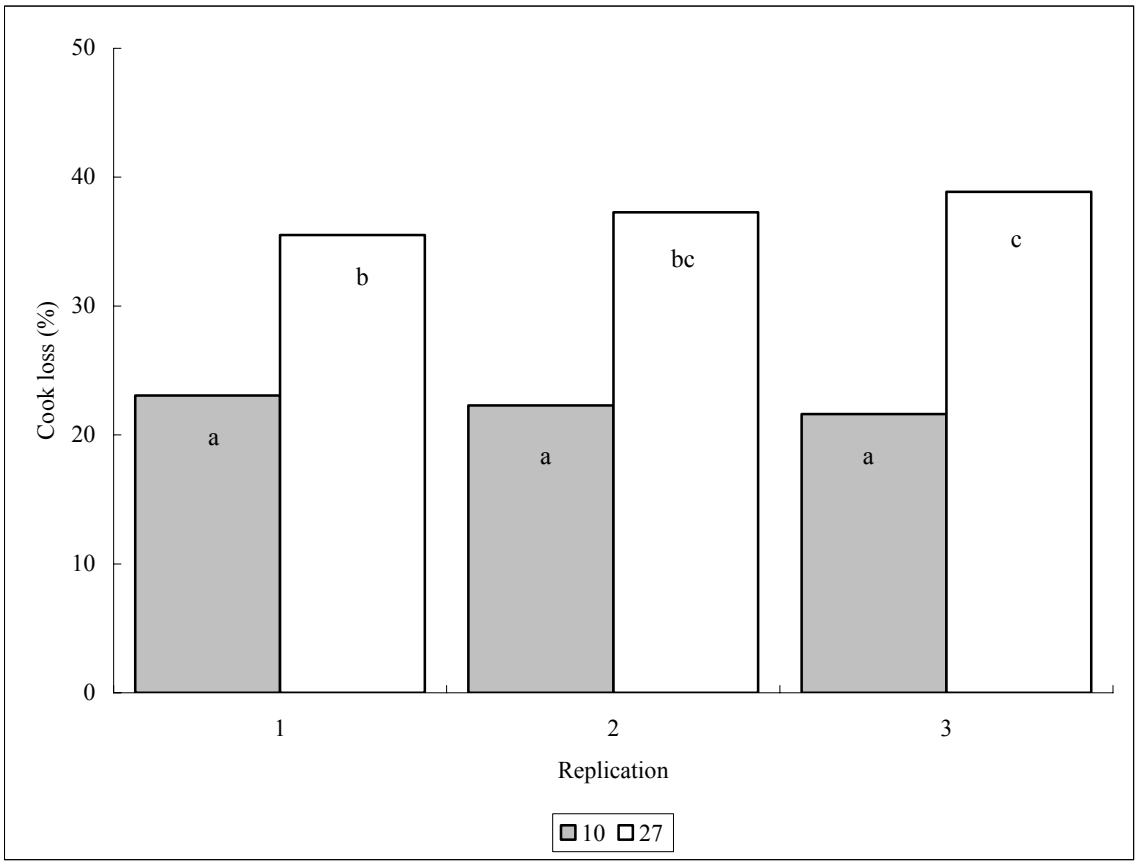


Fig. 6. Least squares means for fat level by replication interaction for cook loss of cooked beef patties ($P = 0.0002$).

[a-c] Mean values followed by the same letter are not significantly different ($P > 0.05$).

Ten percent ground beef patties were not different among replicates (Fig. 6) indicating cook endpoint differences for these patties most likely did not influence these patties. Cook time was longer for replicate 3 ground beef patties (Table 3). Control patties tended to have the shortest cook time, and leaner patties had shorter cook time with the lowest cook loss (Table 3). Water and some fat were released from meat in the form of drip during cooking. The contraction of myosin and actin in lean patties may vary when they are heated above 55^{o}C (Swan and Boles, 2006). The shrunken myosin and actin would expel more water during cooking because water usually stays between the myofibrils and the cell membrane (Huff-Lonergan and Lonergan, 2005). In our study, covariate analysis was conducted where cook time was used as a covariate, in the model for cook loss. Cook time was a significant covariate, and its inclusion in the model explained a variation. Therefore, the difference in cook time appreciably affected cook loss of the patties ($P < 0.05$).

pH and Color of Pre-Cooked Beef Patties

Ground beef patties in replication 3 were lower in pH and CIE a* and b* but higher in CIE L* color space values than the patties from replicates 1 and 2 (Table 4). Replication by storage day interactions for pH value, and CIE L*, a*, b* color space values were observed (P = 0.0001 and P = 0.0002, 0.0022 and 0.0001, respectively) (Figs. 7 and 8). On d 0 of storage, pH of pre-cooked ground beef patties across replicates did not differ (Fig. 7). However, with increased storage, pH for replicates 2 and 3 patties was more consistent. Pre-cooked patties from replicate 1 had higher pH after 3 and 5 d of storage. Generally, under aerobic conditions, multiple types of bacteria may be present initially, but with storage, pseudomonads would most likely grow and proliferate (Adams and Moss, 2003). With increased storage, meat pH would be expectanted to increase and would coincide with an increase in ammonia and amine release due to microbial proteolysis of the meat. These results indicate that pre-cooked patties from replicate 1 most likely had a higher level of microbial growth during storage that would have attributed to the higher pH.

Pre-cooked beef patties from replicate 3 had higher CIE L* and lower CIE a* and b* color space values on d 0 and 3 of storage. Browning of cooked ground beef patties can be affected by air temperature, air flow, cook time and surface temperature of beef when cooked in a convection oven (Wahlby et al., 2000). The higher surface temperature of beef patties produced earlier and greater browning which affected the color of cooked beef patties (Wahlby et al., 2000). However, in our study, pre-cooked beef patties from replicate 3 had longer cook time than others, but had similar internal

Table 4. Main effect least squares means for pH, CIE L*, a*, b*, non-heme iron content and TBARS value of cooked beef patties.

Effect	pH	CIE Color Space Value[c]			Non-heme iron (µg/g)	TBARS (mg/kg)
		L*	a*	b*		
Replication						
P-values	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
1	6.31[f]	45.81[d]	7.83[f]	8.92[e]	6.61[e]	1.55[d]
2	6.25[e]	46.20[d]	8.32[e]	8.91[e]	5.38[d]	1.42[d]
3	6.16[d]	49.22[e]	7.03[d]	7.39[d]	7.21[e]	2.12[e]
Treatment[a]						
P-values	0.9211	0.0001	0.0005	0.0001	0.0004	0.0001
Control	6.22	47.60[f]	8.16[e]	8.86[fg]	6.39[e]	4.38[g]
BHA/BHT	6.25	47.90[f]	8.10[e]	8.65[fg]	5.16[d]	0.78[d]
Rosemary	6.25	47.60[f]	7.97[e]	9.04[g]	5.83[de]	2.45[f]
L. sorghum	6.24	47.41[ef]	7.30[d]	8.34[ef]	6.65[e]	1.33[e]
M. sorghum	6.24	46.54[e]	7.46[d]	8.03[de]	6.60[e]	0.68[d]
H. sorghum	6.26	45.38[d]	7.38[d]	7.52[d]	7.77[f]	0.58[d]
Storage day						
P-values	0.0001	0.0001	0.2297	0.0001	0.0242	0.0001
0	6.20[de]	45.76[d]	7.63	7.51[d]	6.04[d]	0.74[d]
1	6.17[d]	47.50[ef]	7.56	8.27[e]	-	1.32[e]
3	6.25[e]	47.94[f]	7.74	8.50[e]	-	2.07[f]
5	6.35[f]	47.10[e]	7.97	9.36[f]	6.76[e]	2.66[g]
Fat %						
P-values	0.9289	0.0001	0.0001	0.1184	0.0108	0.6874
10	6.24	47.72[e]	8.75[e]	8.53	5.99[d]	1.71
27	6.24	46.63[d]	6.70[d]	8.28	6.81[e]	1.68
Root MSE[b]	0.118	1.768	0.880	0.948	1.313	0.442

[a] Treatments: Control = no antioxidant; BHA/BHT = 0.01% respectively; Rosemary = 0.25%; Low sorghum bran = 0.25%; Medium sorghum bran = 0.5%; High sorghum bran = 1.0% (w/w).
[b] Root Mean Square Error.
[c] CIE color space values: L* = lightness; a* = redness; b* = yellowness.
[defg] Mean values within a column and main effect followed by the same letter are not significantly different ($P > 0.05$).

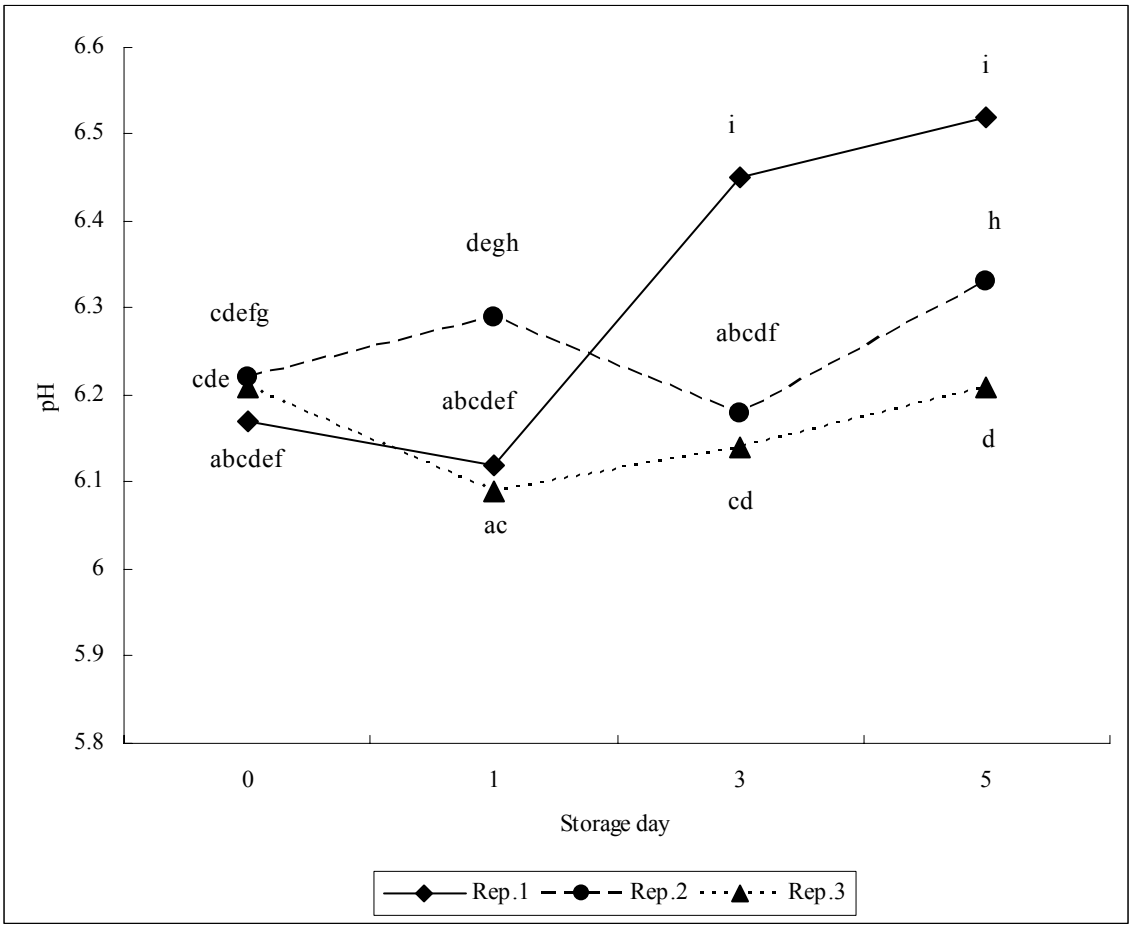
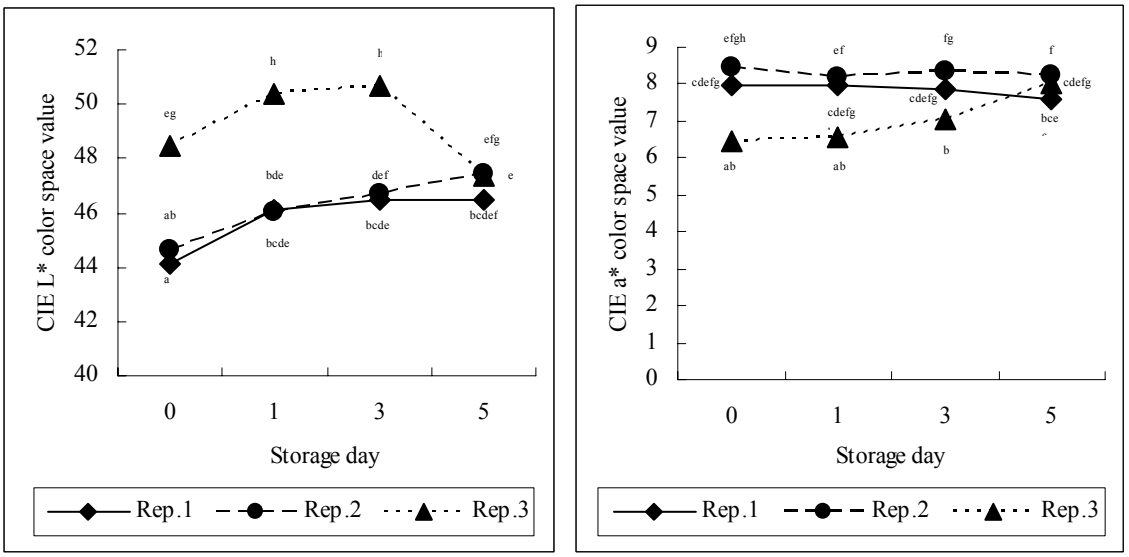


Fig. 7. Least squares means for replication by storage day interaction for pH values of cooked beef patties ($P = 0.0001$).

[a-i] Mean values followed by the same letter are not significantly different ($P > 0.05$).

(a) $P = 0.0002$ (b) $P = 0.0022$



(c) $P = 0.0001$

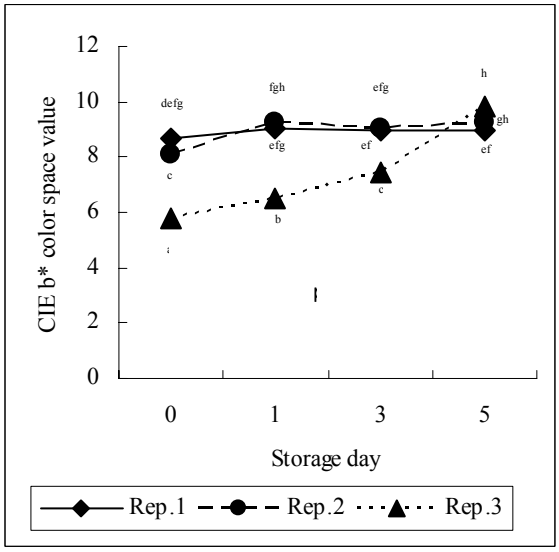


Fig. 8. Least squares means for replication by storage day interaction for CIE L*(a), a*(b) and b*(c) values of cooked beef patties.

CIE color space values: L* = lightness; a* = redness; b* = yellowness.
[a-h] Mean values followed by the same letter are not significantly different ($P > 0.05$).

cooked temperatures (Table 3). This may indicate that lower surface temperature may have been attained and may have resulted in higher CIE L* color space values than the patties from replicates 1 and 2 at d 0 to 3 of storage.

With increased storage to 5 d, the CIE L*, a* and b* color space values did not differ across replicates. As replication effects were found in raw ground beef patties (Table 2), it is not surprising that instrumental color values also would similarly differ in cooked patties. The change of instrumental color values that resulted in no differences after 5 d of storage may be due to the proteolysis of microflora mentioned above. It is assumed that microflora of patties from replicate 3 may have been more dominant than in other replicates and resulted in color differences.

There were significant replication by fat level interactions for pH value, CIE L* and b* color space values ($P = 0.0493$ and $P = 0.0037$ and 0.0001, respectively) (Figs. 9 and 10). Cooked ground beef patties containing 10 or 27% fat from replicate 3 had a lower pH and were lighter, but less yellow than the patties from replicate 1 and 2. Patties from the 27% fat treatment in replicate 1 were darker with a lower level of yellow than the 10% fat patties of replicate 1. In a previous study, Hemphill (2006) demonstrated that 30% fat content raw patties were lighter with more yellow color space values than the patties containing 10% fat. However, a similar trend may not occur in pre-cooked ground beef patties. During cooking, pigments containing compounds are denatured, and color progresses from red to gray. Additionally, browning reactions and dehydration result in the development of dark brown color on the surface. Thus, higher fat patties may produce a darker surface color if heated.

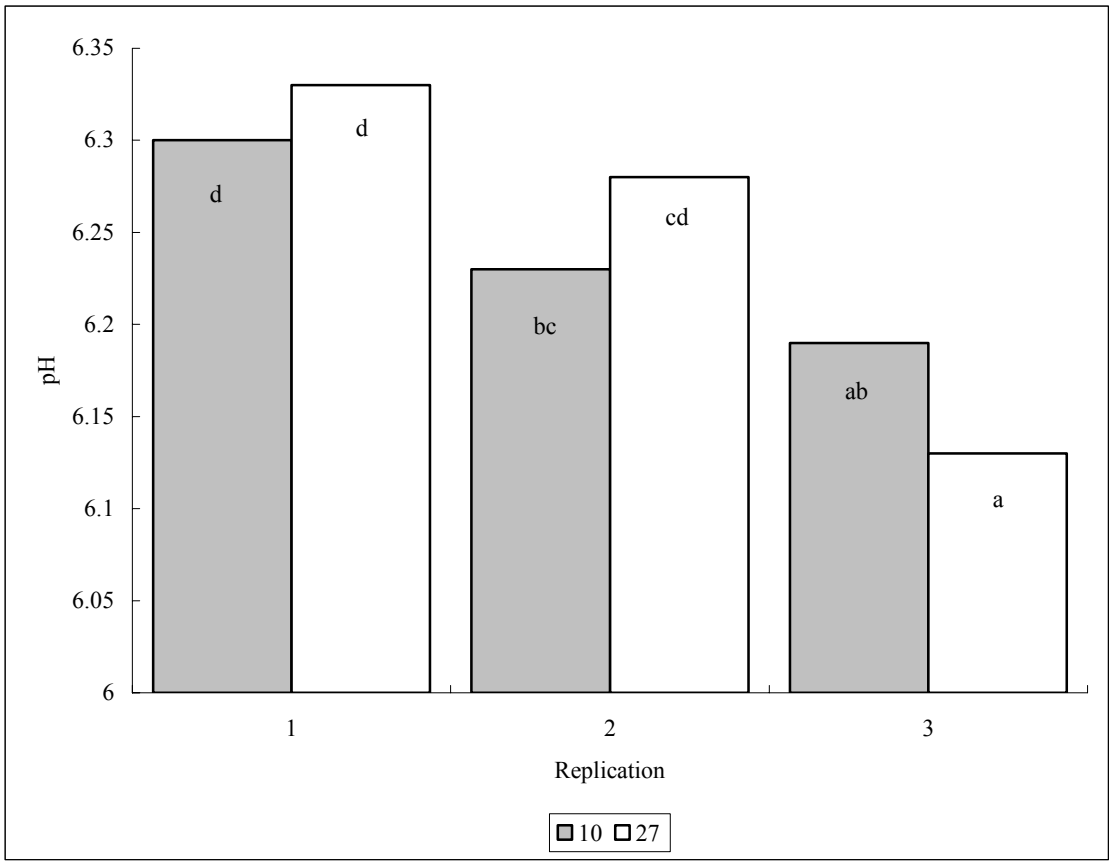
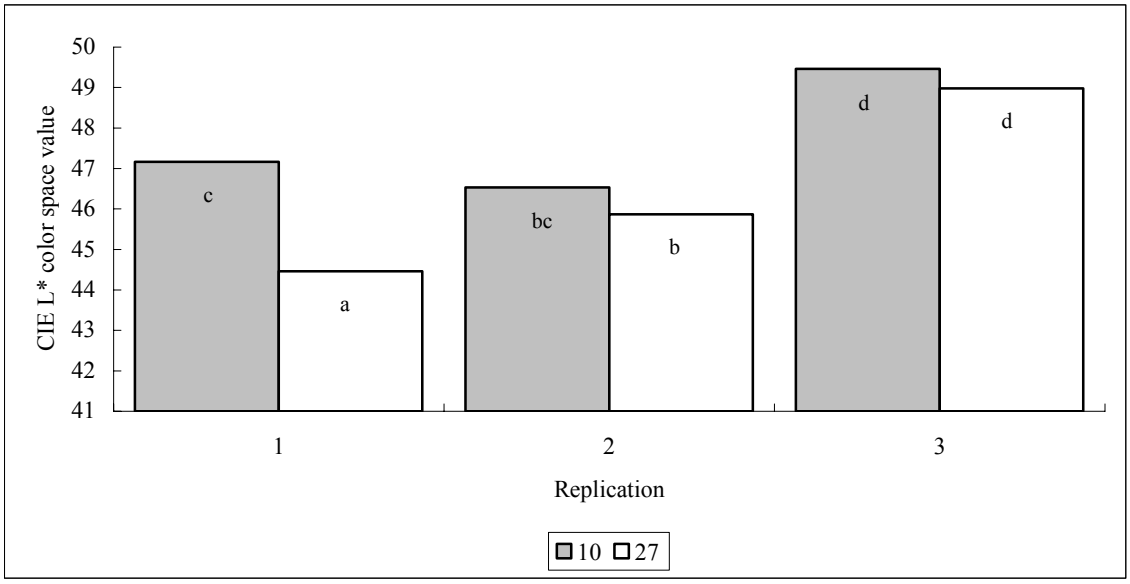


Fig. 9. Least squares means for replication by fat level interaction for pH values of cooked beef patties ($P = 0.0493$).

[a-d] Mean values followed by the same letter are not significantly different ($P > 0.05$).

(a) $P = 0.0037$



(b) $P = 0.0001$

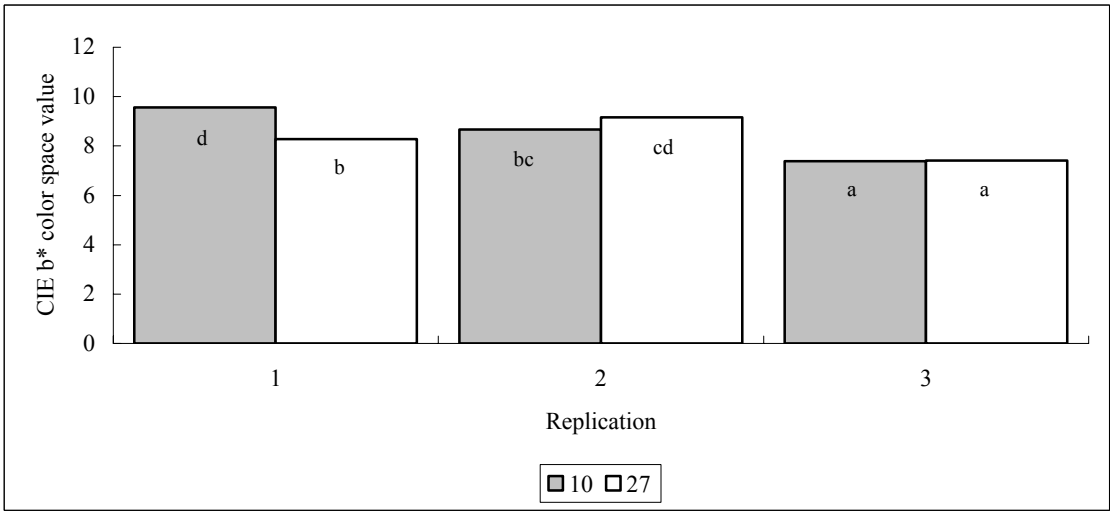


Fig. 10. Least squares means for replication by fat level interaction for CIE L*(a) and b*(b) values of cooked beef patties.

CIE color space values: L* = lightness; b* = yellowness.
[a-d] Mean values followed by the same letter are not significantly different ($P > 0.05$).

Pre-cooked ground beef patties across treatments did not differ in pH (P = 0.92). Pre-cooked ground beef patties containing medium and high levels of sorghum bran were lighter with lower levels of red and yellow than the control patties and patties from other treatments. These trends are similar to color attributes of raw ground beef patties found in Table 2.

Treatment and fat level did not affect pre-cooked beef patty pH; however, pH increased with storage day (P = 0.0001) (Table 4). As shown by Figure 11, there was a treatment by storage day interaction for pH of pre-cooked ground beef patties (P = 0.019). At d 0, control and BHA/BHT treated patties had a higher pH value than patties containing sorghum bran or rosemary, and as the level of sorghum bran increased, pH tended to decrease. With increased storage, pH of pre-cooked beef patties containing low and medium sorghum bran increased slightly. The pH's of patties containing high levels of sorghum bran increased with storage, with a sharper increase in pH from d 3 to 5 of storage. Control patties and those containing BHA/BHT and rosemary decreased in pH from d 0 to 1 of storage and then pH increased slightly with subsequent storage. Changes in pH during storage are most likely a result of microbial growth, and differences in patty pH at d 0 would be due to the result of ingredient addition. As storage time increased, the differential change in pH was most likely a result of microbial growth. As microbiological levels and types were not determined, this effect can not be evaluated.

A fat level and treatment by storage day interaction for pH value of pre-cooked ground beef patties was observed (P = 0.0004) (Fig. 12). The patties containing 10% fat

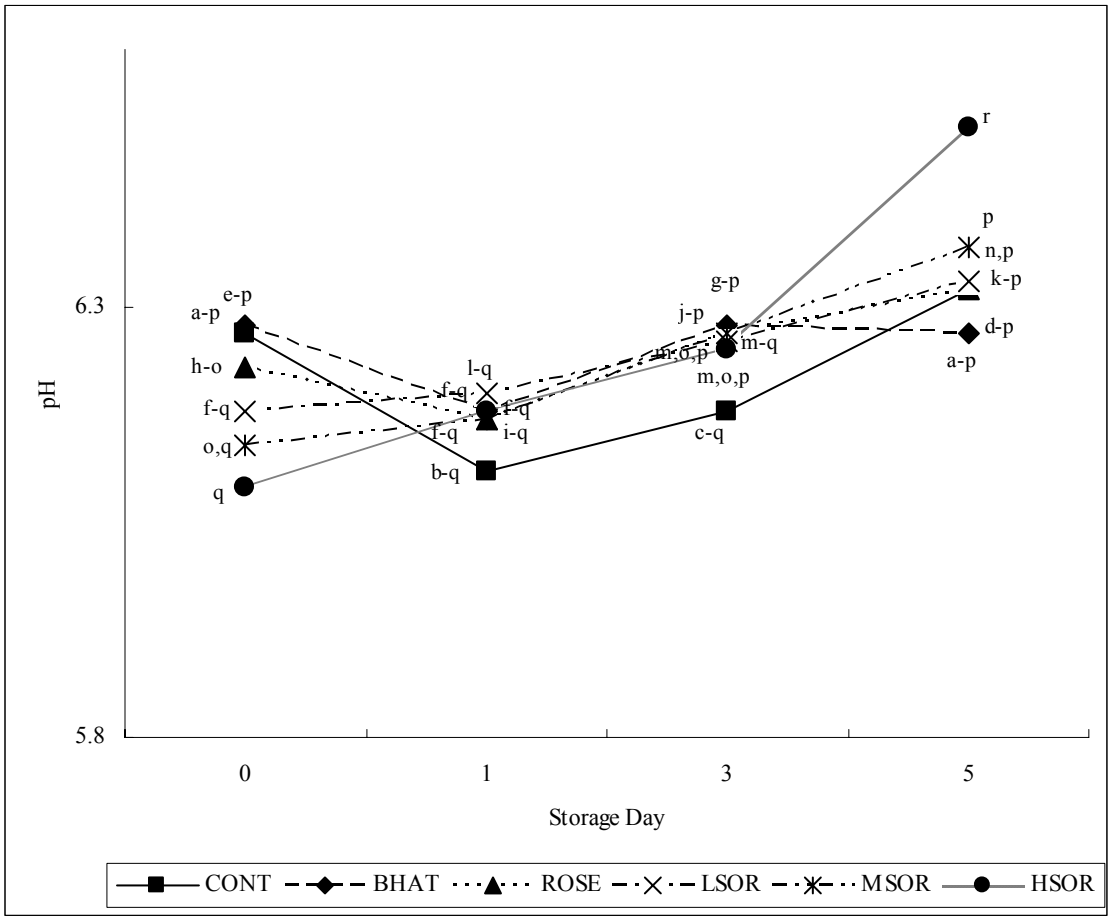


Fig. 11. Least squares means for treatment by storage day interaction for pH values of cooked beef patties ($P = 0.0189$).

Treatments: CON = Control (no antioxidant); BAT = BHA/BHT (0.01% respectively); ROS = Rosemary (0.25%); LSM = Low sorghum bran (0.25%); MSM = Medium sorghum bran (0.5%); HSM = High sorghum bran (1.0%) (w/w). [a-r] Mean values followed by the same letter are not significantly different ($P > 0.05$).

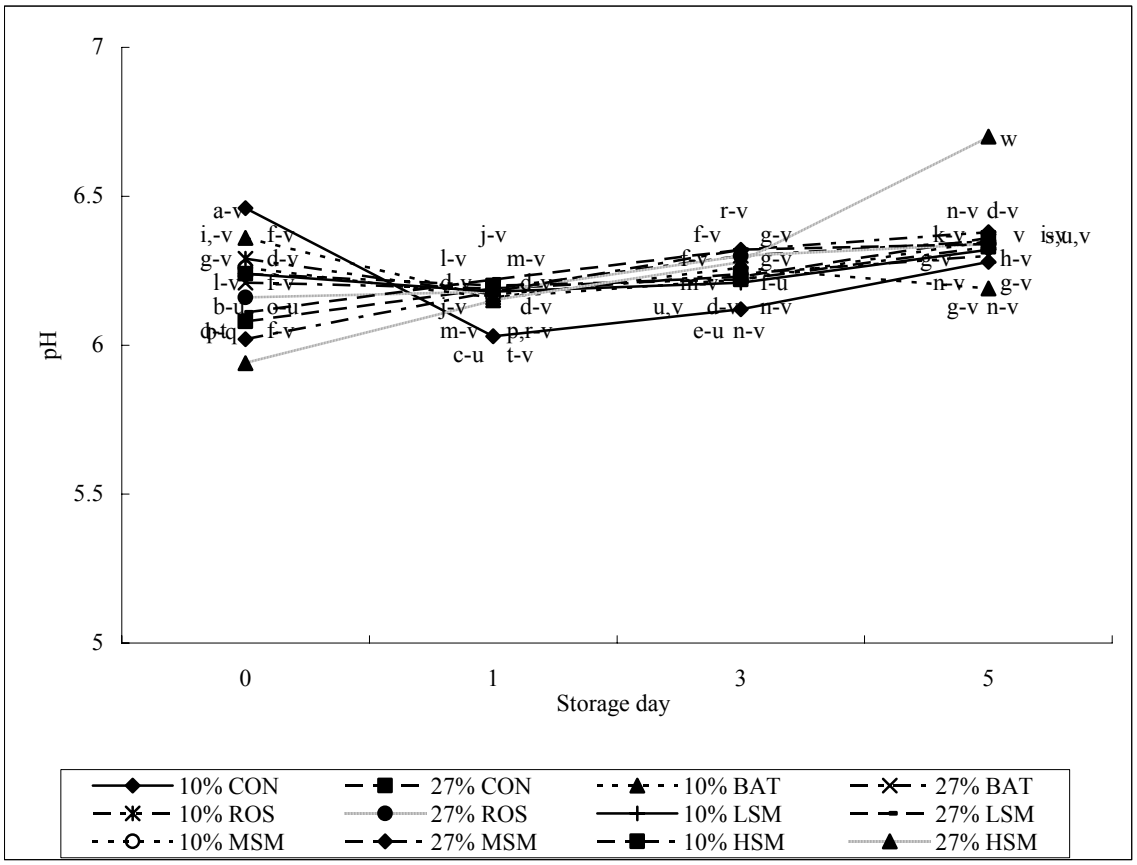


Fig. 12. Least squares means for fat level and treatment by storage day interaction for pH values of cooked beef patties ($P = 0.0004$).

Treatments: CON = Control (no antioxidant); BAT = BHA/BHT (0.01% respectively); ROS = Rosemary (0.25%); LSM = Low sorghum bran (0.25%); MSM = Medium sorghum bran (0.5%); HSM = High sorghum bran (1.0%) (w/w). [a-w] Mean values followed by the same letter are not significantly different ($P > 0.05$).

with antioxidant addition had lower pH values when compared to that of control patties at d 0 of storage. With increased storage differences in pH between patties varying in fat content and treatment decreased, except on d 5 where 27% fat high sorghum bran patties had a high pH. Tannins have been shown to have a slightly negative charge (Thomas and Kelly, 1923). With increased storage in the 27% fat patties, tannins may have been solubilized from the sorghum bran and may have contributed to increased pH. Additionally, increased microbial growth may have induced a higher pH in the 27% fat high sorghum bran patties.

Two reactions might explain the pH increase during storage. One is the growth of aerobic microorganisms, and the other is the increase in reactive oxygen species (ROS). Under aerobic conditions, alkalinity can be measured by concentration of ammonia released from proteins (Kirchmana and Witter, 1989). Due to the growth of microorganisms and/or the reactive oxygen species (ROS) formed by the interaction of the superoxides (O_2^-) and the iron, biochemical changes of beef may be occurring (Shelef and Jay, 1970; Martinaud et al., 1997). Because of the biochemical changes, such as a protein oxidative deamination, an ammonia ion (NH_3^+) may bind to a proton to form ammonium (NH_4^+). Ammonium is a more stabilized form of ammonia (Jay, 2000; Nelson and Cox, 2000). Due to the stabilization of ammonia, pH of the patties would decrease but would rebound quickly during storage. However, because of the microorganisms which break down proteins for their energy (Jay, 2000), more hydrogen ions may be released if less fat is contained in the patties. The patties which contain more protein may show lower pH values than the patties containing less protein.

Treatment affected the lightness, redness and yellowness of pre-cooked ground beef patties (Table 4). Control, BHA/BHT and rosemary treated pre-cooked patties did not differ in color. The addition of a low level of sorghum bran resulted in pre-cooked ground beef patties that had less redness; however, pre-cooked ground beef patties containing medium and high levels of sorghum bran were darker, less red and less yellow. The anthocyanins, tannins and/or other polyphenols of sorghum bran could affect patty color. Anthocyanin compounds are unstable with heating (Ahmed et al., 2004; Suh et al., 2004) and sensitive to light. These compounds may have caused reduced yellow color when they reacted with flavones and flavonols and provided a blue tone after cooking (Kumar and Sinha, 2004). Therefore, the addition of sorghum bran could have reduced red and yellow colors.

With increased storage, pre-cooked ground beef patties were lighter and more yellow, and in higher fat pre-cooked samples, the patties were darker and less red. However, there was a fat level and treatment by storage day interaction for yellowness values (P = 0.0001) (Fig. 13). On d 0 of storage, pre-cooked ground beef patties containing 27% fat had lower CIE b* color space values; as storage increased, yellowness tended to increase in these patties. The yellowness is less correlated to heme pigment and metmyoglobin content and more highly related to brown color (Mancini and Hunt, 2005). Concentration of proteins containing heme pigments may not affect CIE b* color space value of pre-cooked ground beef patties. However, the fat gives a yellow-white color to meat (Serdaroglu, 2006), and color changes of pork sausages due to different fat levels have been reported during storage (Jo et al., 1999). Therefore, CIE

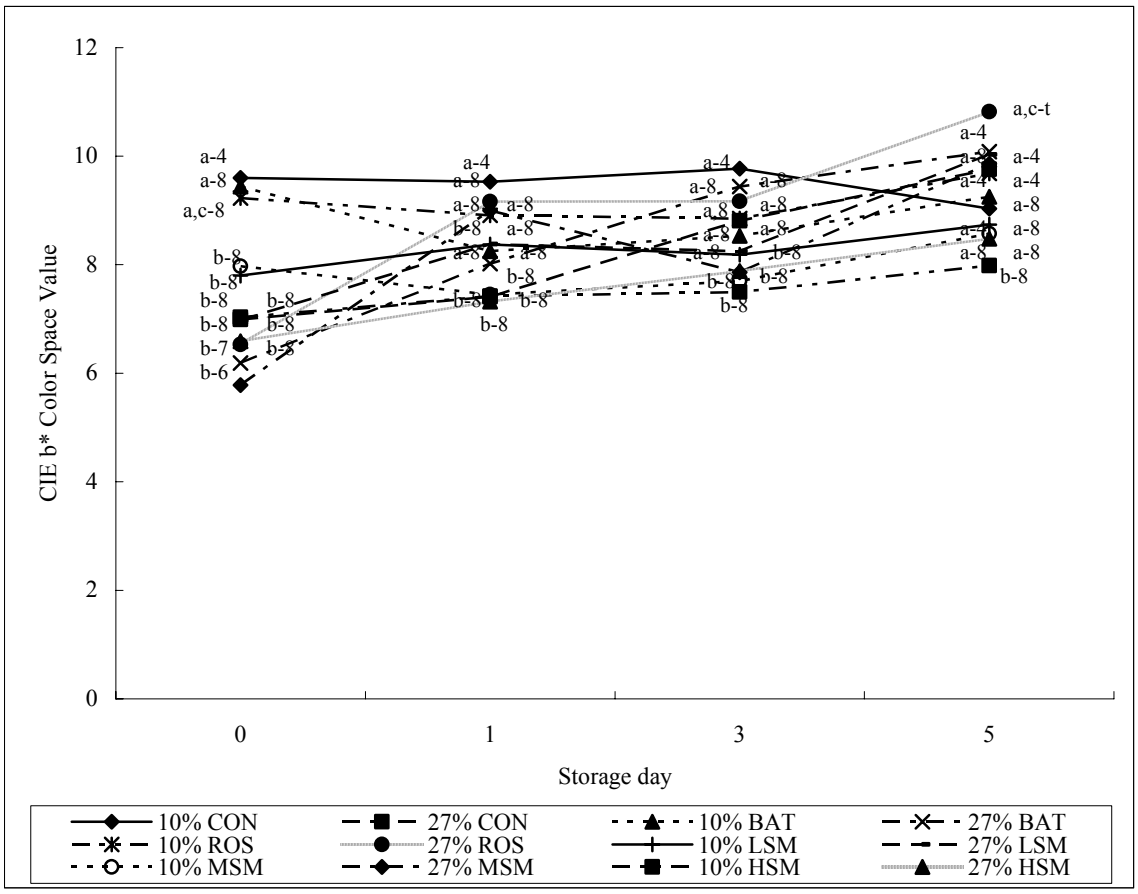


Fig. 13. Least squares means for fat level and treatment by storage day interaction for CIE b* value of cooked beef patties (P = 0.0001).

Treatments: CON = Control (no antioxidant); BAT = BHA/BHT (0.01% respectively); ROS = Rosemary (0.25%); LSM = Low sorghum bran (0.25%); MSM = Medium sorghum bran (0.5%); HSM = High sorghum bran (1.0%) (w/w). [a-z,1-8] Mean values followed by the same letter are not significantly different (P > 0.05).

b* color space value differences were most likely due to fat level difference on the d 0 of storage. While storage increased, light effects on color components distinctively reduced this effect.

Non-heme Iron Content of Pre-Cooked Beef Patties

Lipid oxidation, a naturally occurring process, is triggered by the presence of oxygen, degree of fatty acid saturation and presence of pro-oxidants such as iron and copper (Kanner, 1994). Non-heme iron is a catalyst for lipid oxidation. It is hypothesized that pre-cooked ground beef patties with high non-heme iron content would have higher rates of lipid oxidation as indicated by higher TBARS values. Replication influenced non-heme iron content, and non-heme iron content of pre-cooked ground beef patties was lowest in patties from replicate 2 (Table 4). Additionally, pre-cooked ground beef patties across treatments differed in non-heme iron content. Pre-cooked ground beef patties had higher non-heme iron content than raw ground beef patties indicating a possibility that iron was released from the pigments during cooking (Ahn et al., 1993; Estevez and Cava, 2004) in combination with a concentration effect due to water loss during cooking ($P < 0.05$).

A higher non-heme iron content in pre-cooked ground beef patties, when compared to the raw patties, was expected due to the effect of heating on unfolding and/or denaturation of proteins and the reduction of water and fat through cooking. Pre-cooked ground beef patties containing BHA/BHT had lower non-heme iron content than control patties. Gulcin et al. (2003) reported that the metal chelating activities of BHT

and BHA are 3-14% higher than those of α-tocopherol, a major natural antioxidant, when the same concentration of each antioxidant was supplied. Thus, the heme pigment of the patties containing BHA and BHT would be more stabilized, and thereby less iron may have been released during cooking. Pre-cooked ground beef patties containing rosemary, low and medium sorghum bran had similar non-heme iron content as the control patties. However, pre-cooked ground beef patties with a high level of sorghum had the highest non-heme iron content. Sorghum contains 4.2 mg % of iron expressed on a dry-weight basis (FAO, 1995). The iron contained in sorghum may have influenced the non-heme iron content of raw ground beef as more sorghum bran was added to the patties.

As days of storage increased, non-heme iron content increased slightly. No clear evidence was reported, but the increase in non-heme iron relates to the degradation of the heme pigment. The breakdown of heme molecules due to the oxidative cleavage of porphyrin ring during storage can result in free iron being released from heme (Miller et al., 1994; Lombardi-Boccia et al., 2002). Additionally, Estevez and Cava (2004) reported a close relationship between the protein oxidation and the free iron released from heme pigments, and they reported that more iron was measured when more proteins were oxidized during storage. Therefore, increased reactive oxygen species (ROS) due to the interaction of the singlet oxygen ($^1O_2$) and the heme iron during storage could be considered a major factor in accelerating the oxidative deterioration of the porphyrin ring of myoglobin and could lead to the release of iron from the heme pigments.

The fat level by treatment interactions for non-heme iron content indicated that patties containing antioxidants tended to have higher non-heme iron content when high sorghum bran patties contained 27% fat than 10% fat (P = 0.0199) (Fig. 14). The control patties with 10% fat were expected to have higher non-heme iron content than patties with 27% fat, because more heme pigments may have been available and released in 10% fat pre-cooked ground beef patties during cooking and storage. No differences were found between fat levels from the same treatments except the patties containing high levels of sorghum bran. Due to the different fat levels, the iron content of the patties differed initially. The fat added to patties might work as a buffer, and it also may conduct heat ineffectively during cooking. The patties containing 27% fat required more cook time to reach the final endpoint temperature of 73^{o}C. The increased cook time may have increased the protein denaturation and allow more iron to be released during cooking (Chen et al., 1984). To test this hypothesis, covariate analysis was conducted where cook time and cook loss were used as covariates, respectively, in the model for non-heme iron. However, cook time and cook loss were not significant covariates and their inclusion in the model did not explain additional sources of variation. Therefore, differences in cook time did not appreciably affect non-heme iron content of 27% fat high sorghum bran patties ($P > 0.05$).

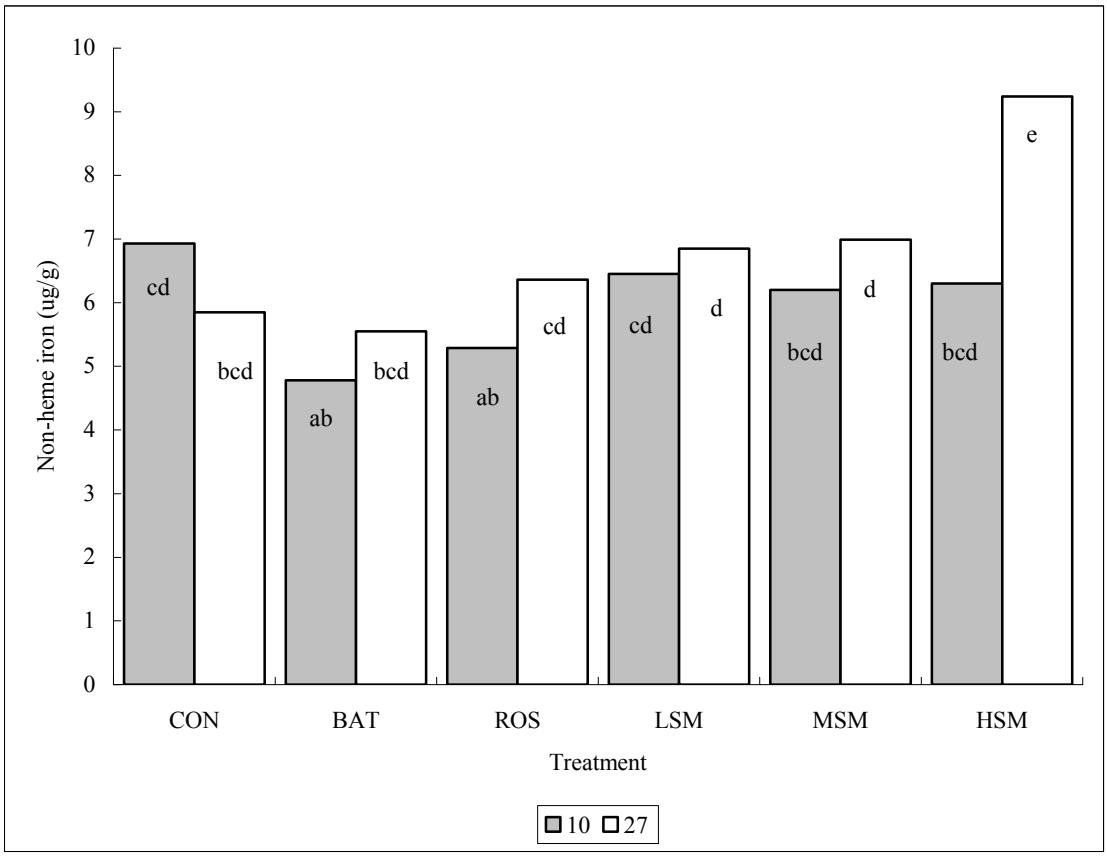


Fig. 14. Least squares means for fat level by treatment interaction for non-heme iron content of cooked beef patties ($P = 0.0208$).

Treatments: CON = Control (no antioxidant); BAT = BHA/BHT (0.01% respectively); ROS = Rosemary (0.25%); LSM = Low sorghum bran (0.25%); MSM = Medium sorghum bran (0.5%); HSM = High sorghum bran (1.0%) (w/w). [a-e] Mean values followed by the same letter are not significantly different ($P > 0.05$).

TBARS Value of Pre-Cooked Beef Patties

TBARS values measure oxidized three-carbon fragments of protein-bound lipids and phospholipids that can not be extracted by an ordinary fat solvent (Tarladgis et al., 1960). A three-carbon fragment produced as a secondary product during lipid oxidation, malonaldehyde, usually forms during the decomposition of hydroperoxides (ROOH). Malonaldehyde may not be broken down during a normal length of storage (Rhee and Myers, 2003). Therefore, to evaluate the effects of sorghum bran addition, TBARS values (mg malonaldehyde/kg) were used to understand the antioxidant properties and the effect of storage time on lipid oxidation. Replication influenced TBARS values, and TBARS values of pre-cooked ground beef patties were the highest in patties from replication 3 (Table 4). Replication by treatment and fat level interactions for TBARS values were shown in Figures 15 and 16 ($P = 0.0001$ and $P = 0.0043$). The pre-cooked ground beef patties from replicate 3 had higher TBARS values than the patties from replicate 1 and 2 in the control, and when rosemary extract and low levels of sorghum bran were added to the patties (Fig. 15). The pre-cooked ground beef patties in replicate 3 also had a higher TBARS value in ground beef patties containing 10% fat (Fig. 16). These results imply that ground beef purchased for replicate 3 was more susceptible to lipid oxidation or may have had higher level of initial lipid oxidation than ground beef purchased for replicates 1 and 2. As replicate effects were reported for raw and cooked patty chemical and color attributes, these results were not surprising.

Pre-cooked ground beef patties across treatments differed in TBARS value ($P = 0.0001$). Treated patties had lower TBARS values than control patties. The addition

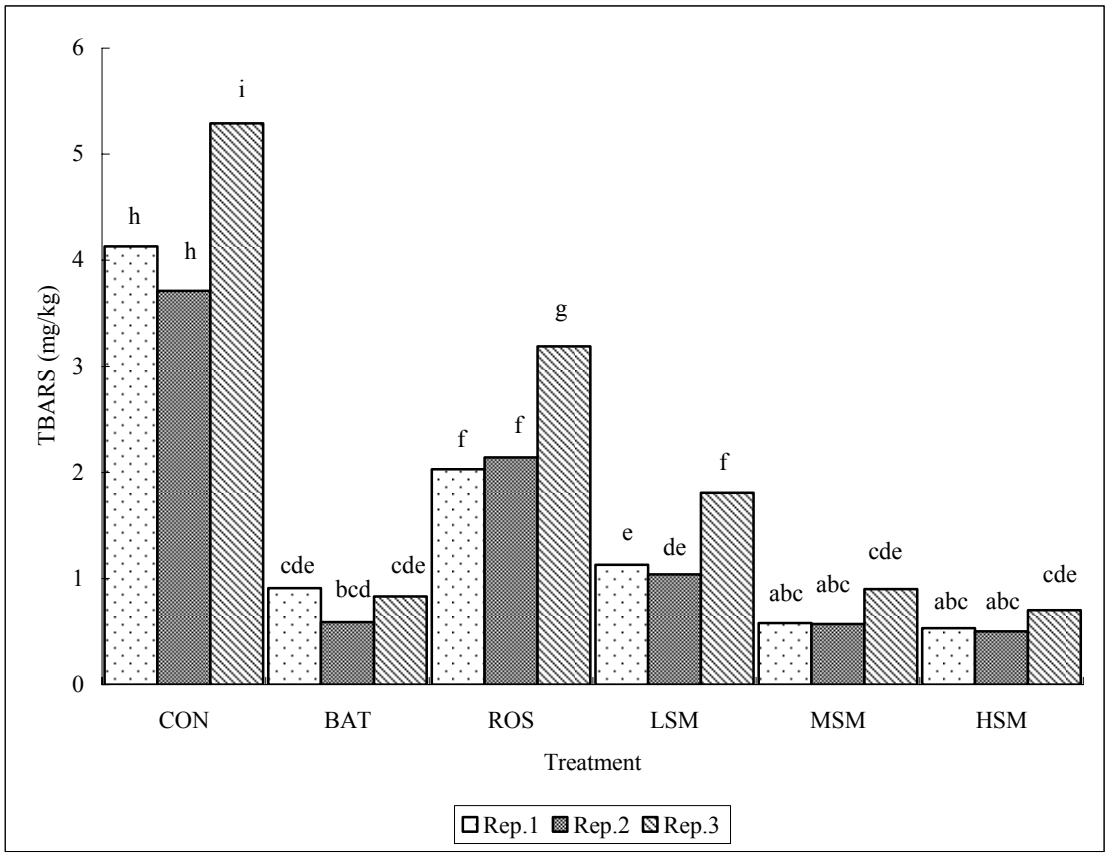


Fig. 15. Least squares means for replication by treatment interaction for TBARS of cooked beef patties ($P = 0.0001$).

Treatments: CON = Control (no antioxidant); BAT = BHA/BHT (0.01% respectively); ROS = Rosemary (0.25%); LSM = Low sorghum bran (0.25%); MSM = Medium sorghum bran (0.5%); HSM = High sorghum bran (1.0%) (w/w). [a-i] Mean values followed by the same letter are not significantly different ($P > 0.05$).

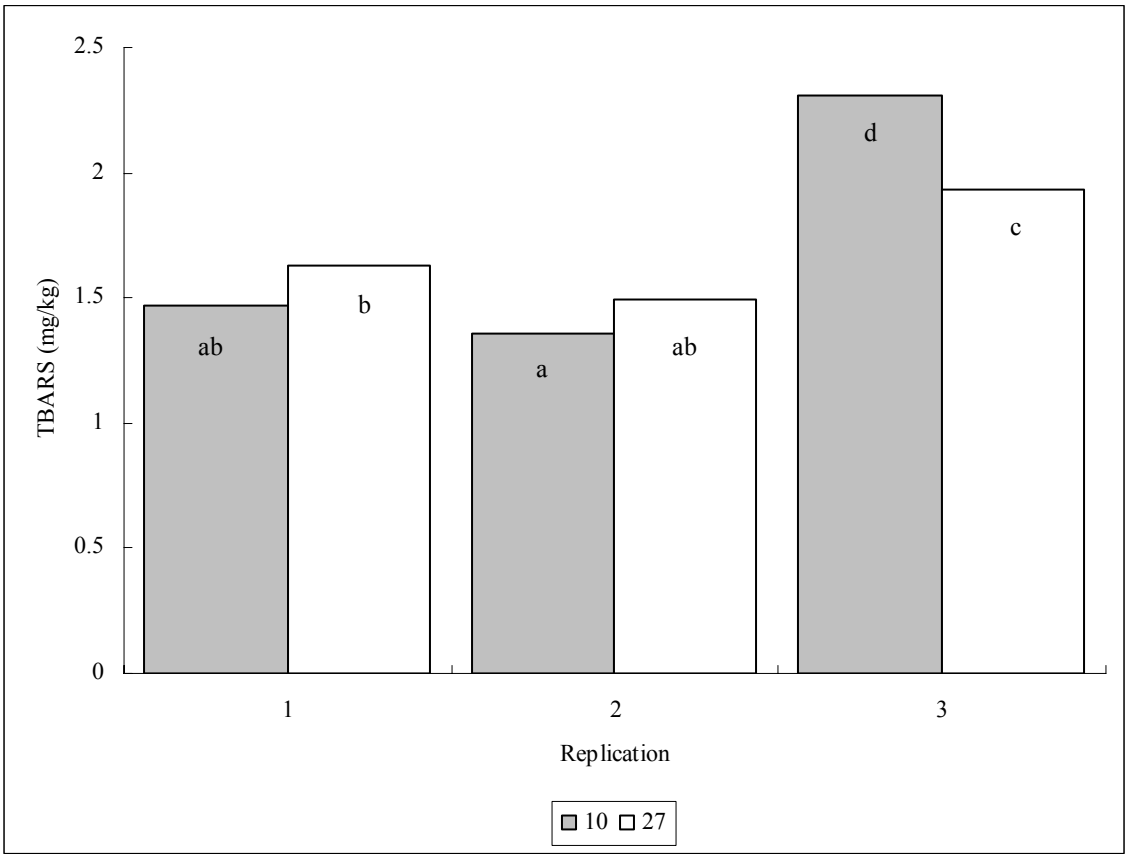


Fig. 16. Least squares means for fat level by replication interaction for TBARS of cooked beef patties ($P = 0.0043$).

[a-d] Mean values followed by the same letter are not significantly different ($P > 0.05$).

of BHA/BHT and medium and high sorghum resulted in the lowest TBARS values in pre-cooked ground beef patties. The fat-soluble BHA/BHT compounds, powerful synthetic antioxidants commonly used in the industry, react preferentially with oxygen and thereby protect the patties from oxidation. However, our study demonstrated the possibility of replacing synthetic antioxidants with sorghum bran, and it is evident that the phenolic compounds such as tannins and anthocyanins of sorghum bran are capable of limiting lipid oxidation by rapidly donating to and/or stealing electrons from free radicals.

Ground beef patties containing rosemary had higher TBARS values than patties from other treatments except for control patties. These results indicate that the addition of rosemary provided some antioxidant activity; however, sorghum bran addition, even at the lowest level, was a more effective antioxidant than rosemary. The rosemary extract and sorghum bran, which contained phenolic compounds, were expected to serve as free-radical scavengers and/or oxygen binders to retard lipid oxidation. Sanchez-Escalante et al. (2001) reported that rosemary contained a large number of compounds such as carnosic acid, carnosol and rosmarinic acid. The rosemary extract is four times as effective as BHA and equal to BHT as an antioxidant (Formanek et al., 2001) or is similar to a mixture of BHA and BHT in breakfast sausage containing 25% mechanically deboned turkey meat (Barbut et al., 1985). Thereby, BHA/BHT and rosemary extract were selected as our primary antioxidants to compare antioxidant effects of sorghum bran. However, the rosemary extract in our study was not as efficient as previous studies (Barbut et al., 1985; Formanek et al., 2001). TBARS values were decreased due to the

increased addition of sorghum bran when compared to control patties. Even though pre-cooked ground beef patties containing three different levels of sorghum bran had similar or higher non-heme iron content, TBARS values of these treatments were lower than control patties.

With advanced storage, TBARS values increased as would be expected; however, there was a treatment by storage day interaction for TBARS values (Fig. 17) (P = 0.0001). On d 0, control patties had higher TBARS values than treated patties. As storage time increased, control patties had concomitantly increased TBARS values. Ground beef patties containing rosemary extract also had increased TBARS values with storage. However, this increase was not as great as seen in control patties, because the rosemary extract most likely acted as a free radical scavenger (Mielnik et al., 2003) and thereby retarded lipid oxidation development. For ground beef patties containing sorghum bran, TBARS values increased with storage in patties containing the low level of sorghum bran. Pre-cooked ground beef patties with medium and high levels of sorghum bran did not increase in TBARS values with storage, and had similar TBARS values as patties containing BHA/BHT.

The addition of sorghum bran at 0.25% in raw ground beef patties has been shown to lower TBARS values (Jenschke, 2004; Hemphill, 2006). Hagerman et al. (1998) also reported that the tannins effectively delayed the lipid oxidation when compared to simple phenolics. Our study indicates that the addition of sorghum bran allows antioxidant activities when sorghum bran was added to ground beef patties and then cooked. Sorghum bran, which contains condensed tannins, anthocyanins and other

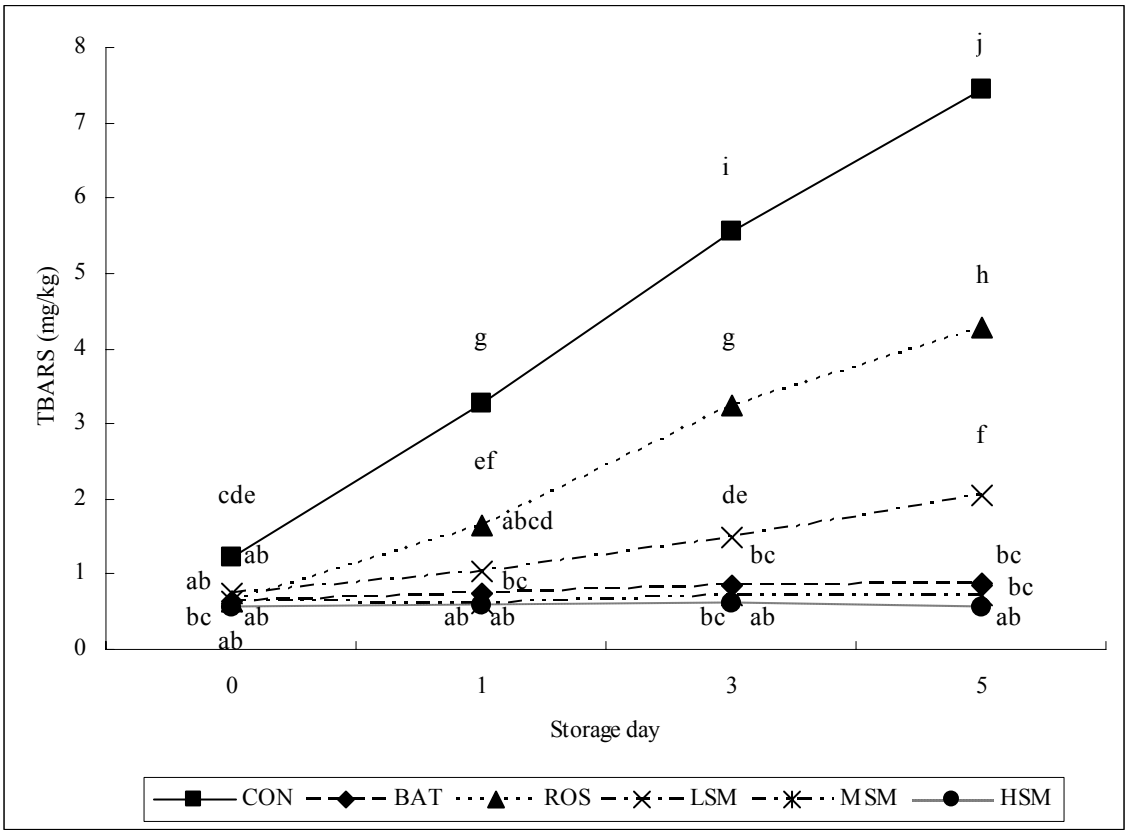


Fig. 17. Least squares means for treatment by storage day interaction for TBARS of cooked beef patties ($P = 0.0001$).

Treatments: CON = Control (no antioxidant); BAT = BHA/BHT (0.01% respectively); ROS = Rosemary (0.25%); LSM = Low sorghum bran (0.25%); MSM = Medium sorghum bran (0.5%); HSM = High sorghum bran (1.0%) (w/w). [a-j] Mean values followed by the same letter are not significantly different ($P > 0.05$).

polyphenols, showed effective antioxidant abilities to scavenge free radicals and/or chelate metal ions when compared to rosemary extract treatment. The strong antioxidant effect of sorghum bran is due to compounds such as 3-deoxyanthocyanidins, which is not common in other natural antioxidants (Awika et al., 2004), or may be due to the combination of lipophilic and hydrophilic antioxidant compounds (Jenschke, 2004; Hemphill, 2006). Due to the combined antioxidant activities of lipophilic and hydrophilic compounds, sorghum bran gives more opportunities to delay lipid oxidation development by providing an effective hurdle effect.

Hemphill (2006) showed less than 1 mg malonaldehyde/kg in raw ground beef patties during 6 d of storage similarly to patties in our study. Their study did not show a greater antioxidant effects with sorghum bran addition when compared to BHA/BHT and rosemary treatments. In our study, the patties were exposed to favorable conditions for lipid oxidation development through cooking, aerobic package and length of storage. Although by the last storage day BHA/BHT and medium and high sorghum brans patties did not have TBARS value that indicated they would be sufficiently oxidized, our study found that sorghum bran can be a competent natural antioxidant in ground beef.

Sensory Evaluation of Pre-Cooked Beef Patties

Sensory evaluation by a trained sensory panel is commonly used to evaluate the effect of lipid oxidation. The flavor and texture changes can occur as a result of lipid oxidation during cooking and storage. Flavor changes during cooking are usually based on the fatty acid composition, and various volatile compounds that could be generated due to Maillard reaction products generat that traditional odor and flavor (Wood et al., 2003). Due to the degradation of lipids, many warmed over flavor (WOF) aromatics described as a 'cardboard-like', 'stale', 'painty' and 'rancid' flavor can be generated during re-heating of stored cooked meat products (Johnson and Civille, 1986; Vega and Brewer, 1994). Warmed over flavor has received more attention with increasing demand of pre-cooked microwaveable foods for consumers' convenience. To evaluate the possible WOF characteristics, Johnson and Civille (1986) stored cooked beef patties for five days and then re-heated in an oven. The re-heated patties were evaluated by trained sensory panels, and they noted that re-heated patties had lower scores for cooked lean beef, cooked beef fat and serumy/bloody aromatics, but higher scores for cardboard, rancid and painty aromatics.

Flavor aromatic attributes, basic tastes, after-tastes, feeling factors, after-feeling factors and textures of pre-cooked beef patties containing synthetic or natural antioxidants are provided in Tables 5, 6, 7, 8, 9 and 10, respectively. Pre-cooked beef patties across replications did not differ in beef/brothy, grainy, musty, burnt and sorghum aromatic flavor, bitter basic taste, sour, burnt and musty after-taste and

Table 5. Main effect least squares means for trained sensory flavor descriptive flavor aromatic beef/brothy, cooked beef fat, grainy and cardboard attribute[a] of cooked beef patties.

Effect	Beef/Brothy	Cooked Beef Fat	Grainy	Cardboard
Replication				
P-values	0.0626	0.0001	0.4441	0.0012
1	3.71	2.75[f]	1.17	1.88[e]
2	3.85	2.76[f]	1.09	1.99[e]
3	3.67	2.27[e]	1.19	1.54[d]
Treatment[b]				
P-values	0.0004	0.0002	0.0854	0.0591
Control	3.42[d]	2.83[f]	1.07	2.13
BHA/BHT	3.66[e]	2.57[de]	1.03	1.65
Rosemary	3.91[f]	2.72[ef]	1.04	1.68
L. sorghum	3.90[f]	2.68[ef]	1.17	1.84
M. sorghum	3.81[ef]	2.41[d]	1.27	1.78
H. sorghum	3.75[ef]	2.36[d]	1.30	1.74
Storage day				
P-values	0.8969	0.0222	0.0155	0.0001
1	3.75	2.52[d]	1.24[e]	1.60[d]
5	3.74	2.67[e]	1.06[d]	2.01[e]
Fat %				
P-values	0.0001	0.0001	0.2475	0.0330
10	3.58[d]	2.30[d]	1.19	1.70[d]
27	3.91[e]	2.89[e]	1.10	1.91[e]
Root MSE[c]	0.2716	0.2642	0.2481	0.3946

[a] Aromatic attributes: 0 = none, 15 = extremely intense.
[b] Treatments: Control = no antioxidant; BHA/BHT = 0.01% respectively; Rosemary = 0.25%; Low sorghum bran = 0.25%; Medium sorghum bran = 0.5%; High sorghum bran = 1.0% (w/w).
[c] Root Mean Square Error.
[d-f] Mean values within a column and main effect followed by the same letter are not significantly different ($P > 0.05$).

Table 6. Main effect least squares means for trained sensory flavor descriptive flavor aromatic musty, burnt and sorghum attribute[a] of cooked beef patties

Effect	Musty	Burnt	Sorghum
Replication			
P-values	0.8400	0.4063	0.0745
1	1.59	1.24	2.04
2	1.60	1.17	1.99
3	1.67	1.39	1.57
Treatment[b]			
P-values	0.0983	0.7625	0.2084
Control	1.65	1.24	1.75
BHA/BHT	1.40	1.29	1.69
Rosemary	1.65	1.26	1.68
L. sorghum	1.68	1.24	1.83
M. sorghum	1.46	1.41	1.91
H. sorghum	1.87	1.16	2.33
Storage day			
P-values	0.8150	0.0525	0.5003
1	1.63	1.38	1.93
5	1.61	1.16	1.80
Fat %			
P-values	0.0001	0.1276	0.0074
10	1.91[e]	1.17	2.12[e]
27	1.33[d]	1.36	1.61[d]
Root MSE[c]	0.3385	0.3290	0.6119

[a] Aromatic attributes: 0 = none, 15 = extremely intense.
[b] Treatments: Control = no antioxidant; BHA/BHT = 0.01% respectively; Rosemary = 0.25%; Low sorghum bran = 0.25%; Medium sorghum bran = 0.5%; High sorghum bran = 1.0% (w/w).
[c] Root Mean Square Error.
[de] Mean values within a column and main effect followed by the same letter are not significantly different ($P > 0.05$).

Table 7. Main effect least squares means for trained sensory flavor descriptive basic taste attributes[a] of cooked beef patties.

Effect	Basic tastes		
	Salt	Sour	Bitter
Replication			
P-values	0.0127	0.0012	0.0658
1	1.09[e]	2.13[d]	2.22
2	1.03[d]	2.34[e]	2.32
3	1.03[d]	2.13[d]	2.36
Treatment[b]			
P-values	0.5666	0.1181	0.0015
Control	1.06	2.29	2.45[e]
BHA/BHT	1.08	2.29	2.40[e]
Rosemary	1.05	2.20	2.18[d]
L. sorghum	1.02	2.18	2.29[de]
M. sorghum	1.05	2.07	2.12[d]
H. sorghum	1.03	2.15	2.37[e]
Storage day			
P-values	0.0003	0.0891	0.9419
1	1.01[d]	2.24	2.30
5	1.09[e]	2.15	2.30
Fat %			
P-values	0.7976	0.0001	0.0003
10	1.05	2.30[e]	2.40[e]
27	1.05	2.09[d]	2.21[d]
Root MSE[c]	0.0839	0.2171	0.2148

[a] Basic taste attributes: 0 = none, 15 = extremely intense.
[b] Treatments: Control = no antioxidant; BHA/BHT = 0.01% respectively; Rosemary = 0.25%; Low sorghum bran = 0.25%; Medium sorghum bran = 0.5%; High sorghum bran = 1.0% (w/w).
[c] Root Mean Square Error.
[de] Mean values within a column and main effect followed by the same letter are not significantly different ($P > 0.05$).

Table 8. Main effect least squares means for trained sensory flavor descriptive after-taste attributes[a] of cooked beef patties.

Effect	After-tastes			
	Sour	Bitter	Burnt	Musty
Replication				
P-values	0.0520	0.0389	0.2645	0.8238
1	1.90	2.03[d]	1.05	1.24
2	2.04	2.15[e]	0.97	1.32
3	1.91	2.15[e]	0.96	0.00
Treatment[b]				
P-values	0.0041	0.1700	0.6123	0.3923
Control	2.11[f]	2.11	0.99	0.00
BHA/BHT	1.98[ef]	2.13	0.98	0.00
Rosemary	1.91[de]	2.11	0.97	0.00
L. sorghum	1.96[ef]	2.14	0.96	0.00
M. sorghum	1.74[d]	1.98	1.09	0.00
H. sorghum	2.02[ef]	2.17	0.97	0.00
Storage day				
P-values	0.8518	0.8530	0.2337	0.3505
1	1.96	2.11	0.96	1.39
5	1.95	2.11	1.02	0.00
Fat %				
P-values	0.0261	0.0520	0.2408	0.0011
10	2.01[e]	2.15	0.96	0.00
27	1.89[d]	2.07	1.03	0.00
Root MSE[c]	0.2198	0.1794	0.1593	0.4378

[a] After taste attributes: 0 = none, 15 = extremely intense.
[b] Treatments: Control = no antioxidant; BHA/BHT = 0.01% respectively; Rosemary = 0.25%; Low sorghum bran = 0.25%; Medium sorghum bran = 0.5%; High sorghum bran = 1.0% (w/w).
[c] Root Mean Square Error.
[d-f] Mean values within a column and main effect followed by the same letter are not significantly different ($P > 0.05$).

Table 9. Main effect least squares means for trained sensory flavor descriptive flavor feeling factor and after-feeling factor[a] of cooked beef patties.

	Feeling Factor		After-Feeling Factor			
Effect	Metallic	Astringent	Metallic	Astringent	Fat Mouthfeel	Sorghum Mouthfeel
Replication						
P-values	0.0001	0.0001	0.0002	0.0013	0.0001	0.8566
1	2.04[d]	2.32[e]	2.00[d]	1.97[d]	1.93[e]	1.53
2	2.17[e]	2.48[f]	2.11[e]	2.19[e]	1.85[e]	1.47
3	2.01[d]	2.14[d]	2.00[d]	2.14[e]	1.50[d]	1.53
Treatment[b]						
P-values	0.0871	0.1970	0.4251	0.5617	0.0159	0.0160
Control	2.08	2.40	2.06	2.19	1.99[f]	1.25[d]
BHA/BHT	2.14	2.39	2.06	2.13	1.69[de]	1.32[de]
Rosemary	2.02	2.22	2.03	2.05	1.83[ef]	1.50[def]
L. sorghum	2.06	2.27	2.07	2.07	1.77[de]	1.53[def]
M. sorghum	2.07	2.31	2.00	2.11	1.68[de]	1.65[ef]
H. sorghum	2.08	2.28	2.01	2.05	1.61[d]	1.81[f]
Storage day						
P-values	0.4100	0.2853	0.7233	0.0648	0.3385	0.4988
1	2.06	2.28	2.03	2.06	1.73	1.55
5	2.08	2.34	2.04	2.15	1.79	1.48
Fat %						
P-values	0.0009	0.0001	0.0484	0.0011	0.0001	0.0003
10	2.11[e]	2.45[e]	2.06[e]	2.18[e]	1.50[d]	1.70[e]
27	2.03[d]	2.03[d]	2.01[d]	2.02[d]	2.02[e]	1.32[d]
Root MSE[c]	0.0971	0.2023	0.0994	0.2047	0.2708	0.3995

[a] Flavor feeling factor and after-feeling factor attributes: 0 = none, 15 = extremely intense.
[b] Treatments: Control = no antioxidant; BHA/BHT = 0.01% respectively; Rosemary = 0.25%; Low sorghum bran = 0.25%; Medium sorghum bran = 0.5%; High sorghum bran = 1.0% (w/w).
[c] Root Mean Square Error.
[d-f] Mean values within a column and main effect followed by the same letter are not significantly different ($P > 0.05$).

Table 10. Main effect least squares means for trained sensory flavor descriptive texture attributes of cooked beef patties.

Effect	Texture			
	Springiness[b]	Hardness[c]	Sandy/Gritty[d]	Juiciness[e]
Replication				
P-values	0.7784	0.0022	0.2852	0.1155
1	6.72	5.39[g]	1.23	2.53
2	6.63	5.39[g]	1.13	2.78
3	6.65	5.67[h]	1.15	2.65
Treatment[a]				
P-values	0.3622	0.1723	0.0171	0.3019
Control	6.58	5.41	1.11[gh]	2.70
BHA/BHT	6.71	5.47	1.06[g]	2.56
Rosemary	6.76	5.55	1.14[gh]	2.88
L. sorghum	6.65	5.40	1.11[gh]	2.66
M. sorghum	6.84	5.68	1.27[hi]	2.61
H. sorghum	6.46	5.38	1.33[i]	2.49
Storage day				
P-values	0.8937	0.3096	0.2921	0.3098
1	6.67	5.44	1.20	2.70
5	6.66	5.52	1.14	2.60
Fat %				
P-values	0.0001	0.0001	0.0001	0.2720
10	6.41[g]	5.28[g]	1.28[h]	2.60
27	6.92[h]	5.68[h]	1.06[g]	2.71
Root MSE[f]	0.4390	0.3126	0.2078	0.4200

[a] Treatments: Control = no antioxidant; BHA/BHT = 0.01% respectively; Rosemary = 0.25%; Low sorghum bran = 0.25%; Medium sorghum bran = 0.5%; High sorghum bran = 1.0% (w/w).
[b] 0 = not springy; 15 = very springy.
[c] 0 = very soft; 15 = very hard.
[d] 0 = none; 15 = very sandy/gritty.
[e] 0 = none; 15 = very juicy.
[f] Root Mean Square Error.
[g-i] Mean values within a column and main effect followed by the same letter are not significantly different ($P > 0.05$).

sorghum mouthfeel after-feeling factor (Tables 5, 6, 7, 8 and 9) ($P > 0.05$). Pre-cooked ground beef patties from replication 3 had lower cooked beef fat, cardboard flavor, salt and sour basic taste, metallic and astringent feeling factor, metallic and fat mouthfeel after-feeling factor, but higher bitter after-taste and astringent after-feeling factor when compared to the patties of replication 1 and 2 ($P < 0.05$). Replication also did not affect the texture of pre-cooked ground beef patties. However, slightly higher hardness values were noted in replication 3 ($P < 0.05$).

Pre-cooked beef patties across treatments did not differ in grainy, cardboard, musty, burnt and sorghum aromatic flavor, salt taste, burnt and musty aftertaste, astringent feeling factor, metallic and astringent after-feeling factor; springiness, hardness and juiciness texture attributes. The addition of antioxidants decreased cooked beef fat flavor, sour after-taste and fat mouthfeel after-feeling factor, but increased beef/brothy flavor and sorghum mouthfeel after-feeling factor. The patties containing rosemary extract were similar in sensory attributes as patties with low sorghum bran addition. The similar trend between rosemary and low sorghum bran may be due to the similar amount of added ingredients used for each treatment.

The addition of medium and high levels of sorghum bran resulted in patties with a lower level of cooked beef fat flavor and fat mouthfeel after-feeling factor (Tables 5 and 9) ($P < 0.05$). The medium and high levels of sorghum bran addition resulted in pre-cooked beef patties with higher levels of beef/brothy flavor and sorghum mouthfeel after-feeling factor when compared to the control patties ($P < 0.05$). The addition of a high level of sorghum bran tended to have lower cooked beef fat flavor and fat

mouthfeel after-feeling factor. In contrast, sorghum mouthfeel after-feeling factor and sandy/gritty texture attribute were increased when more sorghum bran was added. Beef/brothy flavor is a positive flavor note of cooked beef, but cardboard flavor would negatively affect cooked beef flavor during storage (Kulshrestha and Rhee, 1996). The beef/brothy flavor would be abundant if available cysteine and ribose, which are generated from interactions between Maillard reaction products and fatty acids, are increased (Wood et al., 2003). However, the cardboard flavor that is associated with TBARS is commonly applied to measure beef flavor deterioration (Smith and Alfawaz, 1995), and variation in TBARS values would be recorded depending on total lipid content. The total lipid and phospholipids content of ground beef patties (Hemphill, 2006) could be one of the major contributors to the development of WOF (Chen et al., 1984). The directional, but opposite trend, between beef/brothy and cardboardy flavor have been reported (Smith and Alfawaz, 1995; Kulshrestha and Rhee, 1996), but our study did not follow their results.

As storage time increased from 1 to 5 d, pre-cooked ground beef patties had higher levels of cooked beef flavor, cardboard flavor aromatic and salt basic taste and lower levels of grainy flavor aromatic ($P < 0.05$). The formation of grainy flavor would be associated with elevated pH value and myoglobin content (Hemphill, 2006). In our study, higher pH value (pH 6.35) and non-heme iron content (6.76 µg/g) of patties stored 5 d resulted in patties with higher grainy flavors when compared to patties stored 0 d that had a lower pH value (pH 6.20) and non-heme iron content (6.04 µg/g). In addition, our study found that as storage time increased, a loss in the grainy flavor was reported.

Other sensory attributes did not change with storage. Additionally, storage day interactions were not significant ($P > 0.05$) indicating that sensory changes during storage were not affected by fat level or treatment. Tastes and after-tastes indicate the basic tastes found in the mouth during and after evaluation of a sample. Sour and bitter basic tastes and burnt and musty after-taste intensities did not change during storage ($P > 0.05$), but sour and bitter tastes and/or after-taste decreased for ground beef patties with higher fat ($P < 0.05$).

Pre-cooked ground beef patties containing 10% fat had lower levels of cooked beef/brothy, cooked beef fat and cardboard flavor aromatics and higher levels of musty and sorghum flavor aromatics ($P < 0.05$). Additionally, 10% fat pre-cooked ground beef patties were higher in sour and bitter basic tastes; sour after-taste; metallic and astringent feeling factors; and metallic, astringent, fat mouthfeel and sorghum mouthfeel after-feeling factors. Fat level effects on sensory scores showed that as fat level increased, all patties had higher levels for springiness and hardness and had less sandy/gritty attribute. Springiness is the ability of a sample to return to its original shape after being compressed, and hardness is the amount of force involved in biting through a sample (Jenschke, 2004; Hemphill, 2006). Although fatty acid concentration may affect hardness of meat due to the different melting points of the fatty acids (Wood et al., 2003), fat level may have more of an effect on springiness and hardness of patties in this study. Hemphill (2006) also demonstrated that the springiness and hardness of ground beef patties decreased as fat levels increased.

CHAPTER V

SUMMARY

Chemical Characteristics of Raw Beef Patties

This study shows that the ground beef patties containing sorghum bran had lower lightness (L*), redness (a*) and yellowness (b*) color space values but higher non-heme iron content before cooking as compared to control patties. The ground beef patties containing 27% fat had higher pH, lightness (L*), redness (a*), and yellowness (b*) color space values, but lower non-heme iron content than patties containing 10% fat.

Chemical Characteristics of Pre-Cooked Beef Patties

As sorghum bran levels increased, cook time and cook loss were increased when compared to control patties, but these attributes decreased when high sorghum bran was added. Cook loss also increased, and patties containing 27% fat had longer cook time and higher cook loss. The addition of antioxidants resulted in patties with lower redness (a*) color space value, but patties tended to have higher redness (a*) and yellowness (b*) color space values with increased storage days. The addition of a high level of sorghum bran resulted in darker pre-cooked ground beef patties with less redness and yellowness color. As fat level increased, pre-cooked ground beef patties were darker, redder and had less yellow. The pH values of pre-cooked ground beef patties did not differ in beef patties containing different fat levels. The control patties and patties containing BHA/BHT and rosemary extract had lower non-heme iron contents but higher TBARS than the patties containing 1% sorghum bran. In contrast, as sorghum

bran increased, pre-cooked ground beef patties had higher non-heme iron content, but lower TBARS values. The patties containing 27% fat had higher non-heme iron, but had low TBARS values.

Sensory Evaluation

The addition of antioxidants to ground beef patties decreased cooked beef fat flavor, sour after-taste and fat mouthfeel after-feeling factor, but increased beef/brothy flavor and sorghum mouthfeel after-feeling factor attributes. The patties containing rosemary extract were similar in all sensory attributes to the low sorghum bran patties. The sorghum bran addition resulted in patties with higher levels of cooked beef/brothy flavor as compared to control patties. The patties containing the medium and high level of sorghum bran had less cooked beef fat flavor and fat mouthfeel after-feeling factor but higher beef/brothy flavor and sorghum mouthfeel after-feeling factor when compared to the control. As storage day increased, all patties had higher intensity of cooked beef fat and cardboard flavor and salt taste, but lower in grainy flavor. The patties containing 27% fat had higher levels of beef/brothy, cooked beef fat and cardboard flavor, fat mouthfeel after-feeling factor and springiness and hardness of texture, but were lower in musty and sorghum flavor, sour and bitter taste, sour after-taste, metallic and astringent feeling factor, metallic, astringent and sorghum mouthfeel after-feeling factor and sandy/gritty texture than 10% fat patties.

CHAPTER VI

CONCLUSIONS

As pre-cooked ground beef patties were stored up to five days, lipid oxidation occurred. The addition of sorghum bran at 0.5 and 1.0% (w/w) in pre-cooked ground beef was as effective in limiting lipid oxidation development as BHA/BHT. Even though medium and high levels of sorghum bran had the greatest effect in reducing lipid oxidation during storage when compared to the control, sorghum bran addition resulted in lower pre-cooked patties color space values and changed the beef/brothy and cooked beef fat flavor attributes of pre-cooked patties. Additionally, although the use of 0.5 and 1.0% sorghum bran had similar TBARS values over time, pre-cooked patties containing 0.5% sorghum bran was more similar in color to control patties. Therefore, the use of 0.5% sorghum bran in pre-cooked beef patties would limit lipid oxidation and not negatively affect raw and cooked beef color and sensory attributes. Further studies on a sorghum extraction using water or ethanol might be necessary to remove undesirable or unnecessary chemical compounds and consequently reduce the negative effects of sorghum bran on color, and sensory flavor and texture attributes.

LITERATURE CITED

Adams, M. R., and M. O. Moss. 2003. Food Microbiology. The Royal Society of Chemistry. Athenaeum Press Ltd., Gateshead, Tyne and Wear, UK.

Ahmed, J., U. S. Shivhare, and G. S. V. Raghavan. 2004. Thermal degradation kinetics of anthocyanin and visual colour of plum puree. Eur. Food Res. Technol. 218:525-528.

Ahn, J., I. U. Gruen, and L. N. Fernando. 2002. Antioxidant properties of natural plant extracts containing polyphenolic compounds in cooked ground beef. J. Food Sci. 67:1364-1369.

Ahn, D. U., F. H. Wolfe, and J. S. Sim. 1993. Three methods for determining nonheme iron in turkey meat. J. Food Sci. 58:288-291.

American Meat Science Association (AMSA). 1995. Research guidelines for cookery, sensory evaluation and instrumental tenderness measurements of fresh meat. Am. Meat Sci. Assoc., Savory, IL.

Angelo, A. J. St. 1996. Lipid oxidation in foods. Crit. Rev. Food Sci. Nutr. 36:175-224.

Angelo, A. J. St., and M. E. Bailey. 1987. Warmed-over Flavor of Meat. Academic Press, Inc., Orlando, FL.

Awika, J. M. 2000. Sorghum phenols as antioxidants. M.S. thesis, Texas A&M University, College Station, TX.

Awika, J. M., L. Dykes, L. Gu, L. W. Rooney, and R. L. Prior. 2003a. Processing of sorghum and sorghum products alters procyanidin oligomer and polymer distribution and content. J. Agric. Food Chem. 51:5516-5521.

Awika, J. M., and L. W. Rooney. 2004. Sorghum phytochemicals and their potential impact on human health. Phytochemistry. 65:1199-1221.

Awika, J. M., L. W. Rooney, and R. D. Waniska. 2004. Anthocyanins from black sorghum and their antioxidant properties. Food Chem. 90:293-301.

Awika, J. M., L. W. Rooney, X. Wu, R. L. Prior, and L. Cisneros-Zevalios. 2003b. Screening method to measure antioxidant activity of sorghum (*Sorghum bicolor*) and sorghum products. J. Agric. Food Chem. 51:6657-6662.

Barbut, S., D. B. Josephson, and A. J. Maurer. 1985. Antioxidant properties of rosemary oleoresin in turkey sausage. J. Food Sci. 50:1356-1359.

Baron, C. P., and H. J. Andersen. 2002. Myoglobin-induced lipid oxidation. A review. J. Agric. Food Chem. 50:3887-3897.

Beninger, C. W., and G. L. Hosfield. 2003. Antioxidant activity of extracts, condensed tannin fractions, and pure flavonoids from *Phaseolus vulgaris* L. Seed coat color Genotypes. J. Agric. Food Chem. 51:7879-7883.

Boles, J. A., and J. E. Swan. 2002. Heating method and final temperature affect processing characteristics of beef semimebranosus muscle. Meat Sci. 62:107-112.

Boyer, R. F., and C. J. McCleary. 1987. Superoxide ion as a primaty reductant in ascorbate-mediated ferritin iron release. Free Radical Biol. Med. 3:389-395.

Brewer, M. S., and J. Novakofski. 1999. Cooking rate, pH and final endpoint temperature effects on color and cook loss of a lean ground beef model system. Meat Sci. 52:443-451.

Brune, M., L. Rossander, and L. Hallberg. 1989. Iron absorption and phenolic compounds: Importance of different phenolic structures. Eur. J. Clin. Nutr. 43:547-558.

Butler, A. J., and D. K. Larick. 1993. Effect of antioxidants on the sensory characteristics and storage stability of aseptically processed low-fat beef gels. Meat Sci. 35:355-369.

Chen, C. C., A. M. Pearson, J. I. Gray, M. H. Fooladi, and P. K. Ku. 1984. Some factors influencing the nonheme iron content of meat and its implications in oxidation. J. Food Sci. 49:581-584.

Cook, N. C., and S. Samman. 1996. Flavonoids-chemistry, metabolism, cardioprotective effects and dietary sources. Nutr. Biochem. 7:66-76.

Decker, E. A., C. Faustman, and C. Lopez-Bote. 2000. Antioxidants in Muscle Foods. John Wiley and Sons, Inc., New York, NY.

Decker, E. A., and B. Welch. 1990. Role of ferritin as a lipid oxidation catalyst in muscle food. J. Agric. Food Chem. 38:674-677.

Estevez, M., and R. Cava. 2004. Lipid and protein oxidation, release of iron from heme molecule and colour deterioration during refrigerated storage of liver pate. Meat Sci. 68:551-558.

Fang, Y. Z., S. Yang, and G. Wu. 2002. Free radicals, antioxidants, and nutrition. Nutrition. 18:872-879.

Food and Agriculture Organization of the United Nations (FAO). 1995. Sorghum and millets in human nutrition. David Lubin Menorial Library Cataloguing in Publication Data FAO, Rome (Italy). FAO Food and Nutrition Series, No. 27. ISBN 92-5-103381-1.

Formanek, Z., J. P. Kerry, F. M. Higgins, D. J. Buckley, P. A. Morrissey, and J. Farkas. 2001. Addition of synthetic and natural antioxidants to α-tocopheryl acetate supplemented beef patties: Effects of antioxidants and packaging on lipid oxidation. Meat Sci. 58:337-341.

Frankel, E. N., and A. S. Meyer. 2000. The problems of using one-dimensional methods to evaluate multifunctional food and biological antioxidants. J. Sci. Food Agric. 80:1925-1941.

Grun, I. U., J. Ahn, A. D. Clarke, and L. L. Carol. 2006. Reducing oxidation of meat. Food Tech. 60:36-43.

Gulcin, I., M. E. Buyukokuroglu, and O. I. Kufrevioglu. 2003. Metal chelating and hydrogen peroxide scavenging effects of melatonin. J. Pineal. Res. 34:278-281.

Guntensperger, B., E. Hammerli-Meier, and F. E. Escher. 1998. Rosemary extract and precooking effects on lipid oxidation in heat-sterilized meat. J. Food Sci. 63:955-957.

Gutteridge, J. M. C., and B. Halliwell. 1990. The measurement and mechanism of lipid peroxidation in biological systems. Trends Biochem. Sci. 15:129-135.

Gutteridge, J. M. C., R. Richmond, and B. Halliwell. 1979. Inhibition of iron-catalysed formation of hydroxyl radicals from superoxide and of lipid peroxidation by desferrioxamine. Biochem. J. 184:473-476.

Hagerman, A. E., K. M. Riedl, G. Alexander Jones, K. N. Sovik, N. T. Ritchard, P. W. Hartzfeld, and T. L. Riechel. 1998. High molecular weight plant polyphenolics (Tannins) as biological antioxidants. J. Agric. Food Chem. 46:1887-1892.

Harel, S., and J. Kanner. 1985. Hydrogen peroxide generation in ground muscle tissues. J. Agric. Food Chem. 33:1186-1188.

Hemingway, R. W., and P. E. Laks. 1992. Plant Polyphenols. Plenurn Press, New York, NY.

Hemphill, S. P. 2006. Effect of sorghum bran addition on lipid oxidation and sensory properties of ground beef patties differing in fat levels. M.S. Thesis, Texas A&M University, College Station, TX.

Huff-Lonergan, E. and S. M. Lonergan. 2005. Mechanisms of water-holding capacity of meat: the role of postmortem biochemical and structural changes. Meat Sci. 71:194-204.

Jackson, T. C., G. R. Acuff, C. Vanderzant, T. R. Sharp, and J. W. Savell. 1992. Identification and evaluation of volatile compounds of vacuum and modified atmosphere packaged beef strip loins. Meat Sci. 31:175-190.

Jakobsen, M., and G. Bertelsen. 2000. Colour stability and lipid oxidation of fresh beef. Development of a response surface model for predicting the effects of temperature, storage time, and modified atmosphere composition. Meat Sci. 54:49-57.

Jay, J. M. 2000. Modern Food Microbiology. 6th ed. Aspen Publishers, Inc., Gaithersburg, MD.

Jenschke, B. E. 2004. Chemical, color and sensory attributes of sorghum bran enhanced beef patties in a high oxygen environment. M.S. thesis, Texas A&M University, College Station, TX.

Jo, C., J. I. Lee, and D. U. Ahn. 1999. Lipid oxidation, color changes and volatiles production in irradiated pork sausage with different fat content and packaging during storage. Meat Sci. 51:355-361.

John, L., D. Cornforth, C. E. Carpenter, O. Sorheim, B. C. Pettee, and D. R. Whittier. 2004. Comparison of color and thiobarbituric acid values of cooked hamburger patties after storage of fresh beef chubs in modified atmospheres. J. Food Sci. 69:C608-C614.

Johnson, P. B., and G. V. Civille. 1986. A standardized lexicon of meat WOF descriptors. J. Sens. Stud. 1:99-104.

Kanner, J. 1994. Oxidative processes in meat and meat products: quality implications. Meat Sci. 36:169-189.

Kanner, J., I. Shegalovich, S. Harel, and B. Hazan. 1988. Muscle lipid peroxidation dependent on oxygen and free metal ions. J. Agric. Food Chem. 36:409-412.

Kay, C. D., and B. J. Holub. 2002. The effect of wild blueberry (*Vaccinium angustifolium*) consumption on postprandial serum antioxidant status in human subjects. Br. J. Nutr. 88:389-397.

Kim, D. O., S. W. Jeong, and C. Y. Lee. 2003. Antioxidant capacity of phenolic phytochemicals from various cultivars of plums. Food Chem. 81:321-326.

Kirchmana, H., and F. Witter. 1989. Ammonia volatilization during aerobic and anaerobic manure decomposition. Plant Soil 115:35-41.

Kristensen, I., and P. P. Purslow. 2001. The effect of processing temperature and addition of mono- and di-valent salts on the heme- nonheme-iron ratio in meat. Food Chem. 73:433-439.

Kulshrestha, S. A., and K. S. Rhee. 1996. Precooked reduced-fat patties chemical and sensory quality as affected by sodium ascorbate, lactate and phosphate. J. Food Sci. 61:1052-1057.

Kumar, J. K., and A. K. Sinha. 2004. Resurgence of natural colourants: A holistic view. Natr. Pro. Lett. 18:59-84.

Ladikos, D., and V. Lougovois. 1990. Lipid oxidation in muscle foods: A review. Food Chem. 35:295-314.

Lindley, P. F. 1996. Iron in biology: A structural viewpoint. Rep. Prog. Phys. 59:867-933.

Lombardi-Boccia, G., B. Martinez-Dominguez, and A. Aguzzi. 2002. Total heme and non-heme iron in raw and cooked meats. J. Food Sci. 67:1738-1741.

Lukogorskaya, S. A., I. V. Shugalei, and I. V. Tselinskii. 2002. Peroxide damage of hemoglobin by the fenton system. Russian J. Gen. Chem. 72:480-483.

Mancini, R. A., and M. C. Hunt. 2005. Current research in meat color. Meat Sci. 71:100-121.

Martinaud, A., Y. Mercier, P. Marinova, C. Tassy, P. Catellier, and M. Renerre. 1997. Comparison of oxidative processes on myofibrillar proteins from beef during maturation and by different model oxidation systems. J. Agric. Food Chem. 45:2481-2487.

Meilgaard, M., G. V. Civille, and B. T. Carr. 1999. Sensory Evaluation Techniques, 3rd ed. CRC Press LLC, Boca Raton, FL.

Mielnik, M. B., K. Aaby, and G. Skrede. 2003. Commercial antioxidants control lipid oxidation in mechanically deboned turkey meat. Meat Sci. 65:1147-1155.

Miller, D. K., J. V. Gomez-Basauri, V. L. Smith, J. Kanner, and D. D. Miller. 1994. Dietary iron in swine rations affects nonheme iron and TBARS in pork skeletal muscles. J. Food Sci. 59:747-749.

Miller, D. M., G. R. Buettner, and S. D. Aust. 1990. Transition metals as catalysts of "Autoxidation" reactions. Free Radi. Bio. Med. 8:95-108.

Minotti, G., and S. D. Aust. 1987. The requirement for iron(III) in the initiation of lipid peroxidation by iron(II) and hydrogen peroxide. J. Biol. Chem. 262:1098-1104.

Mitsumoto, M., M. N. O'Grady, J. P. Kerry, and D. J. Buckley. 2005. Addition of tea catechins and vitamin C on sensory evaluation, colour and lipid stability during chilled storage in cooked or raw beef and chicken patties. Meat Sci. 69:773-779.

Murphy, A., J. P. Kerry, J. Buckley, and I. Gray. 1998. The antioxidative properties of rosemary oleoresin and inhibition of off-flavours in precooked roast beef slices. J. Sci. Food Agric. 77:235-243.

Nelson, D. L., and M. M. Cox. 2000. Lehninger's Principles of Biochemistry. 3rd ed. Worth Publishers, New York, NY.

Rhee, K. S. 1978. Minimization of further lipid peroxidation in the distillation of 2-thiobarbituric acid test of fish and meat. J. Food Sci. 43:1776-1778, 1781.

Rhee, K. S., and C. E. Myers, C. E. 2003. Sensory properties and lipid oxidation in aerobically refrigerated cooked ground goat meat. Meat Sci. 66:189-194.

Rhee, K. S., and Y. A. Ziprin. 1987. Modification of the schricker nonheme iron method to minimize pigment effects for red meats. J. Food Sci. 52:1174-1176.

Ryter, S. W., and R. M. Tyrrell. 2000. The heme synthesis and degradation pathways: role in oxidant sensitivity. Free Radic. Biol. Med. 28:289-309.

SAS. 1998. SAS User Guide to Statistics (Version 6.12). SAS Inst. Inc., Cary, NC.

Sanchez-Escalante, A., D. Djenane, G. Torrescano, J. A. Beltran, and P. Roncales. 2001. The effects of ascorbic acid, taurine, carnosine and rosemary powder on colour and lipid stability of beef patties packaged in modified atmosphere. Meat Sci. 58:421-429.

Schricker, B. R., D. D. Miller, and J. R. Stouffer. 1982. Measurement and content of nonheme and total iron in muscle. J. Food Sci. 47:740-743.

Sebranek, J. G., V. J. H. Sewalt, K. L. Robbins, and T. A. Houser. 2005. Comparison of a natural rosemary extract and BHA/BHT for relative antioxidant effectiveness in pork sausage. Meat Sci. 69:289-296.

Seideman, S. C., and P. R. Durland. 1984. The effect of cookery on muscle proteins and meat palatability: A review. J. Food Qual. 6:291-314.

Serdaroglu, M. 2006. The characteristics of beef patties containing different levels of fat and oat flour. Int. J. Food Sci. and Tech. 41:147-153.

Shelef, L. A., and J. M. Jay. 1970. Use of a titrimetric method to assess the bacterial spoilage of fresh beef. Appl. Micobiol. 19:902-905.

Smith, J. S., and M. Alfawaz. 1995. Antioxidative activity of maillard reaction products in cooked ground beef, sensory and TBA values. J. Food Sci. 60:234-236, 240.

Suh, H. J., J. M. Kim, H. Lee, S. W. Lee, and Y. M. Choi. 2004. Thermal kinetics on antiradical capacity of mulberry fruit extract. Eur. Food Res. Technol. 219:80-83.

Swan, J. E., and J. A. Boles. 2006. Functionality of cow beef in coarse and fine ground model systems. Meat Sci. 72:25-33.

Tang, S., D. Sheehan, D. J. Buckley, P. A. Morrissey, and J. P. Kerry. 2001. Anti-oxidant activity of added tea catechins on lipid oxidation of raw minced red meat, poultry and fish muscle. Int. J. Food Sci. and Tech. 36:685-692.

Tarladgis, B. G., B. M. Watts, M. T. Younathan, and L. R. Dugan. 1960. Distillation method for the quantitative determination of malonaldehyde in rancid foods. J. Am. Oil Chem. Soc. 37:44-48.

Thomas, A. W., and M. W. Kelly. 1923. Concentration factor in the combination of tannin with hide substance. Industrial Engin. Chem. 15:928.

Tims, M. J., and B. M. Watts. 1958. Protection of cooked meats with phosphates. Food Tech. 12:240-243.

Vega, J. D'Dios., and M. S. Brewer. 1994. Dectectable odor thresholds of selected lipid oxidation compounds at various temperatures in a gelatin model system. J. Food Lipids 1:229-245.

Wahlby, U., C. Skjoldebrand, and E. Junker. 2000. Impact of impingement on cooking time and food quality. J. Food Eng. 43:179-187.

Wood, J. D., R. I. Richardson, G. R. Nute, A. V. Fisher, M. M. Campo, E. Kasapidou, P. R. Sheard, and M. Enser. 2003. Effects of fatty acids on meat quality: A review. Meat Sci. 66:21-32.

Yasosky, J. J., E. D. Aberle, I. C. Peng, E. W. Mills, and M. D. Judge. 1984. Effects of pH and time of grinding on lipid oxidation of fresh ground pork. J. Food Sci. 49:1510-1512.

Zhao, Y., J. H. Wells, and K. W. McMillin. 1994. Applications of dynamic modified atmosphere packaging systems for fresh red meats: review. J. Muscle Foods 5:299-328.

APPENDIX A

AOV TABLES

Table A-1. ANOVA table for the moisture content of raw beef patties, %

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	831.0053417	166.2010683		
Error	6	1.0585500	0.1764250		
Corrected Total	11	832.0638917			
Rep	2	22.9448667	11.4724333	65.03	<.0001
Fat	1	803.4396750	803.4396750	4554.00	<.0001
Rep*Fat	2	4.6208000	2.3104000	13.10	0.0065

Table A-2. ANOVA table for the fat content of raw beef patties, %

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	519.0995417	103.8199083		
Error	6	0.6675500	0.1112583		
Corrected Total	11	519.7670917			
Rep	2	17.0986167	8.5493083	76.84	<.0001
Fat	1	499.6170750	499.6170750	4490.60	<.0001
Rep*Fat	2	2.3838500	1.1919250	10.71	0.0105

Table A-3. ANOVA table for pH values of raw beef patties

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	8	1.21695494	0.15211937		
Error	27	0.57552562	0.02131576		
Corrected Total	35	1.79248056			
Rep	2	0.93798518	0.46899259	22.00	<.0001
Trt	5	0.03668704	0.00733741	0.34	0.8814
Fat	1	0.24228272	0.24228272	11.37	0.0023

Table A-4. ANOVA table for L* values of raw beef patties

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	10	465.0965457	46.5096546		
Error	25	19.0695901	0.7627836		
Corrected Total	35	484.1661358			
Rep	2	12.0819432	6.0409716	7.92	0.0022
Trt	5	75.1171914	15.0234383	19.70	<.0001
Fat	1	347.9053938	347.9053938	456.10	<.0001
Rep*Fat	2	29.9920173	14.9960086	19.66	<.0001

Table A-5. ANOVA table for a* values of raw beef patties

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	15	502.1882898	33.4792193		
Error	20	12.5244395	0.6262220		
Corrected Total	35	514.7127293			
Rep	2	5.9394821	2.9697410	4.74	0.0206
Trt	5	51.9066238	10.3813248	16.58	<.0001
Fat	1	409.7700522	409.7700522	654.35	<.0001
Rep*Fat	2	9.7099525	4.8549762	7.75	0.0032
Trt*Fat	5	24.8621793	4.9724359	7.94	0.0003

Table A-6. ANOVA table for b* values of raw beef patties

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	15	116.6642272	7.7776151		
Error	20	4.2939605	0.2146980		
Corrected Total	35	120.9581877			
Rep	2	5.38524506	2.69262253	12.54	0.0003
Trt	5	5.02890988	1.00578198	4.68	0.0054
Fat	1	99.53387778	99.53387778	463.60	<.0001
Rep*Fat	2	1.52662407	0.76331204	3.56	0.0477
Trt*Fat	5	5.18957037	1.03791407	4.83	0.0046

Table A-7. ANOVA table for non-heme iron contents of raw beef patties, µg/g

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	8	82.9854987	10.3731873		
Error	27	151.6018577	5.6148836		
Corrected Total	35	234.5873564			
Rep	2	18.16834642	9.08417321	1.62	0.2170
Trt	5	53.16942259	10.63388452	1.89	0.1285
Fat	1	11.64772973	11.64772973	2.07	0.1613

Table A-8. ANOVA table for internal cook temperatures of pre-cooked beef patties, ^{o}C

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	18	54.5476736	3.0304263		
Error	125	99.8646701	0.7989174		
Corrected Total	143	154.4123438			
Rep	2	7.50697917	3.75348958	4.70	0.0108
Trt	5	12.58223958	2.51644792	3.15	0.0103
Day	3	8.60977431	2.86992477	3.59	0.0156
Fat	1	2.01876736	2.01876736	2.53	0.1144
Rep*Fat	2	10.88336806	5.44168403	6.81	0.0016
Trt*Fat	5	12.94654514	2.58930903	3.24	0.0087

Table A-9. ANOVA table for cook times of pre-cooked beef patties, min

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	11	301.7760417	27.4341856		
Error	132	387.4583333	2.9352904		
Corrected Total	143	689.2343750			
Rep	2	23.4479167	11.7239583	3.99	0.0207
Trt	5	46.3489583	9.2697917	3.16	0.0100
Day	3	0.6857639	0.2285880	0.08	0.9719
Fat	1	231.2934028	231.2934028	78.80	<.0001

Table A-10. ANOVA table for cook losses of pre-cooked beef patties

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	13	8069.804318	620.754178		
Error	126	933.237552	7.406647		
Corrected Total	139	9003.041871			
Rep	2	22.077970	11.038985	1.49	0.2292
Trt	5	152.445593	30.489119	4.12	0.0017
Day	3	50.352871	16.784290	2.27	0.0840
Fat	1	7682.698051	7682.698051	1037.27	<.0001
Rep*Fat	2	136.629420	68.314710	9.22	0.0002

Table A-11. ANOVA table for pH values of pre-cooked beef patties

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	57	3.75107662	0.06580836		
Error	86	1.19742701	0.01392357		
Corrected Total	143	4.94850363			
Rep	2	0.57607886	0.28803943	20.69	<.0001
Trt	5	0.01972284	0.00394457	0.28	0.9211
Day	3	0.72228958	0.24076319	17.29	<.0001
Fat	1	0.00011142	0.00011142	0.01	0.9289
Rep*Day	6	1.02572454	0.17095409	12.28	<.0001
Rep*Fat	2	0.08679923	0.04339961	3.12	0.0493
Trt*Day	15	0.43259861	0.02883991	2.07	0.0189
Trt*Day*Fat	23	0.88775154	0.03859789	2.77	0.0004

Table A-12. ANOVA table for L* values of pre-cooked beef patties

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	19	722.639266	38.033646		
Error	124	387.538955	3.125314		
Corrected Total	143	1110.178222			
Rep	2	333.7022019	166.8511009	53.39	<.0001
Trt	5	108.0933581	21.6186716	6.92	<.0001
Day	3	96.1373583	32.0457861	10.25	<.0001
Fat	1	59.5683816	59.5683816	19.06	<.0001
Rep*Day	6	88.4337549	14.7389592	4.72	0.0002
Rep*Fat	2	36.7042117	18.3521059	5.87	0.0037

Table A-13. ANOVA table for a* values of pre-cooked beef patties

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	17	229.6066013	13.5062707		
Error	126	97.4752616	0.7736132		
Corrected Total	143	327.0818629			
Rep	2	40.7056177	20.3528089	26.31	<.0001
Trt	5	18.3252615	3.6650523	4.74	0.0005
Day	3	3.3799089	1.1266363	1.46	0.2297
Fat	1	150.2190686	150.2190686	194.18	<.0001
Rep*Day	6	16.9767446	2.8294574	3.66	0.0022

Table A-14. ANOVA table for b* values of pre-cooked beef patties

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	57	333.7895588	5.8559572		
Error	86	77.3268511	0.8991494		
Corrected Total	143	411.1164099			
Rep	2	74.04032886	37.02016443	41.17	<.0001
Trt	5	38.37187469	7.67437494	8.54	<.0001
Day	3	62.39639074	20.79879691	23.13	<.0001
Fat	1	2.23668642	2.23668642	2.49	0.1184
Rep*Day	6	61.87902731	10.31317122	11.47	<.0001
Rep*Fat	2	20.54822978	10.27411489	11.43	<.0001
Trt*Day*Fat	38	74.31702099	1.95571108	2.18	0.0016

Table A-15. ANOVA table for non-heme iron contents of pre-cooked beef patties, µg/g

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	14	133.6934930	9.5495352		
Error	57	98.2416760	1.7235382		
Corrected Total	71	231.9351689			
Rep	2	41.49328834	20.74664417	12.04	<.0001
Trt	5	45.91918542	9.18383708	5.33	0.0004
Day	1	9.23674829	9.23674829	5.36	0.0242
Fat	1	11.97442727	11.97442727	6.95	0.0108
Trt*Fat	5	25.06984365	5.01396873	2.91	0.0208

Table A-16. ANOVA table for TBARS values of pre-cooked beef patties, mg/kg

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	38	472.8987934	12.4447051		
Error	104	20.2984813	0.1951777		
Corrected Total	142	493.1972747			
Rep	2	13.1412244	6.5706122	33.66	<.0001
Trt	5	263.5027550	52.7005510	270.01	<.0001
Day	3	76.3099038	25.4366346	130.33	<.0001
Fat	1	0.0317884	0.0317884	0.16	0.6874
Rep*Trt	10	8.1211903	0.8121190	4.16	<.0001
Rep*Fat	2	2.2413158	1.1206579	5.74	0.0043
Trt*Day	5	109.1081026	7.2738735	37.27	<.0001

Table A-17. ANOVA table for the sensory aromatic beef/brothy

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	14	5.97488426	0.42677745		
Error	57	4.20567130	0.07378371		
Corrected Total	71	10.18055556			
Rep	2	0.42937500	0.21468750	2.91	0.0626
Trt	5	2.00537037	0.40107407	5.44	0.0004
Day	1	0.00125000	0.00125000	0.02	0.8969
Fat	1	1.95580247	1.95580247	26.51	<.0001
Trt*Fat	5	1.58308642	0.31661728	4.29	0.0022

Table A-18. ANOVA table for the sensory aromatic cooked beef fat

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	12	13.92063272	1.16005273		
Error	59	4.11881173	0.06981037		
Corrected Total	71	18.03944444			
Rep	2	3.77340278	1.88670139	27.03	<.0001
Trt	5	2.00925926	0.40185185	5.76	0.0002
Day	1	0.38524691	0.38524691	5.52	0.0222
Fat	1	6.30125000	6.30125000	90.26	<.0001
Rep*Fat	2	1.05145833	0.52572917	7.53	0.0012
Day*Fat	1	0.40001543	0.40001543	5.73	0.0199

Table A-19. ANOVA table for the sensory aromatic grainy

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	9	1.35326685	0.15036298		
Error	42	2.58423315	0.06152936		
Corrected Total	51	3.93750000			
Rep	2	0.10184661	0.05092330	0.83	0.4441
Trt	5	0.64354281	0.12870856	2.09	0.0854
Day	1	0.39143506	0.39143506	6.36	0.0155
Fat	1	0.08460850	0.08460850	1.38	0.2475

Table A-20. ANOVA table for the sensory aromatic cardboard

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	9	7.44739838	0.82748871		
Error	59	9.18814107	0.15573120		
Corrected Total	68	16.63553945			
Rep	2	2.36491287	1.18245643	7.59	0.0012
Trt	5	1.76745062	0.35349012	2.27	0.0591
Day	1	2.87359862	2.87359862	18.45	<.0001
Fat	1	0.74202872	0.74202872	4.76	0.0330

Table A-21. ANOVA table for the sensory aromatic musty

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	9	4.78069634	0.53118848		
Error	39	4.46873677	0.11458299		
Corrected Total	48	9.24943311			
Rep	2	0.04014467	0.02007234	0.18	0.8400
Trt	5	1.15282095	0.23056419	2.01	0.0983
Day	1	0.00636084	0.00636084	0.06	0.8150
Fat	1	3.69907035	3.69907035	32.28	<.0001

Table A-22. ANOVA table for the sensory aromatic burnt

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	9	1.76745333	0.19638370		
Error	31	3.35449789	0.10820961		
Corrected Total	40	5.12195122			
Rep	2	0.20071674	0.10035837	0.93	0.4063
Trt	5	0.27885752	0.05577150	0.52	0.7625
Day	1	0.43998903	0.43998903	4.07	0.0525
Fat	1	0.26525470	0.26525470	2.45	0.1276

Table A-23. ANOVA table for the sensory aromatic sorghum

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	9	8.15047089	0.90560788		
Error	39	14.60037945	0.37436870		
Corrected Total	48	22.75085034			
Rep	2	2.08028348	1.04014174	2.78	0.0745
Trt	5	2.83035588	0.56607118	1.51	0.2084
Day	1	0.17327876	0.17327876	0.46	0.5003
Fat	1	2.99141833	2.99141833	7.99	0.0074

Table A-24. ANOVA table for the sensory basic taste salt

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	9	0.19651620	0.02183513		
Error	62	0.43644290	0.00703940		
Corrected Total	71	0.63295910			
Rep	2	0.06602623	0.03301312	4.69	0.0127
Trt	5	0.02751929	0.00550386	0.78	0.5666
Day	1	0.10250386	0.10250386	14.56	0.0003
Fat	1	0.00046682	0.00046682	0.07	0.7976

Table A-25. ANOVA table for the sensory basic taste sour

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	11	2.61803627	0.23800330		
Error	60	2.82788580	0.04713143		
Corrected Total	71	5.44592207			
Rep	2	0.71329475	0.35664738	7.57	0.0012
Trt	5	0.43427855	0.08685571	1.84	0.1181
Day	1	0.14074460	0.14074460	2.99	0.0891
Fat	1	0.79170139	0.79170139	16.80	0.0001
Rep*Day	2	0.53801698	0.26900849	5.71	0.0054

Table A-26. ANOVA table for the sensory basic taste bitter

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	9	1.97300154	0.21922239		
Error	62	2.86144290	0.04615230		
Corrected Total	71	4.83444444			
Rep	2	0.26256944	0.13128472	2.84	0.0658
Trt	5	1.02962963	0.20592593	4.46	0.0015
Day	1	0.00024691	0.00024691	0.01	0.9419
Fat	1	0.68055556	0.68055556	14.75	0.0003

Table A-27. ANOVA table for the sensory after taste sour

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	9	1.48694830	0.16521648		
Error	62	2.99564043	0.04831678		
Corrected Total	71	4.48258873			
Rep	2	0.29982253	0.14991127	3.10	0.0520
Trt	5	0.93455633	0.18691127	3.87	0.0041
Day	1	0.00170139	0.00170139	0.04	0.8518
Fat	1	0.25086806	0.25086806	5.19	0.0261

Table A-28. ANOVA table for the sensory after taste bitter

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	9	0.60746528	0.06749614		
Error	62	1.99577160	0.03218986		
Corrected Total	71	2.60323688			
Rep	2	0.22040123	0.11020062	3.42	0.0389
Trt	5	0.25955633	0.05191127	1.61	0.1700
Day	1	0.00111497	0.00111497	0.03	0.8530
Fat	1	0.12639275	0.12639275	3.93	0.0520

Table A-29. ANOVA table for the sensory after taste burnt

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	9	0.18887908	0.02098656		
Error	31	0.78673067	0.02537841		
Corrected Total	40	0.97560976			
Rep	2	0.07048950	0.03524475	1.39	0.2645
Trt	5	0.09155676	0.01831135	0.72	0.6123
Day	1	0.03743429	0.03743429	1.48	0.2337
Fat	1	0.03630122	0.03630122	1.43	0.2408

Table A-30. ANOVA table for the sensory after taste musty

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	10	3.91053154	0.39105315		
Error	27	5.17499478	0.19166647		
Corrected Total	37	9.08552632			
Rep	2	0.07482673	0.03741337	0.20	0.8238
Trt	5	1.03741124	0.20748225	1.08	0.3923
Day	1	0.17301632	0.17301632	0.90	0.3505
Fat	1	2.53580158	2.53580158	13.23	0.0011
Rep*Day	1	1.09647326	1.09647326	5.72	0.0240

Table A-31. ANOVA table for the sensory feeling factor metallic

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	9	0.55160880	0.06128987		
Error	62	0.58431327	0.00942441		
Corrected Total	71	1.13592207			
Rep	2	0.33412809	0.16706404	17.73	<.0001
Trt	5	0.09552855	0.01910571	2.03	0.0871
Day	1	0.00648534	0.00648534	0.69	0.4100
Fat	1	0.11546682	0.11546682	12.25	0.0009

Table A-32. ANOVA table for the sensory feeling factor astringent

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	9	3.26391590	0.36265732		
Error	62	2.53688272	0.04091746		
Corrected Total	71	5.80079861			
Rep	2	1.43694444	0.71847222	17.56	<.0001
Trt	5	0.31072917	0.06214583	1.52	0.1970
Day	1	0.04753472	0.04753472	1.16	0.2853
Fat	1	1.46870756	1.46870756	35.89	<.0001

Table A-33. ANOVA table for the sensory after feeling factor metallic

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	12	0.59833333	0.04986111		
Error	59	0.58277778	0.00987759		
Corrected Total	71	1.18111111			
Rep	2	0.19881944	0.09940972	10.06	0.0002
Trt	5	0.04944444	0.00988889	1.00	0.4251
Day	1	0.00125000	0.00125000	0.13	0.7233
Fat	1	0.04013889	0.04013889	4.06	0.0484
Rep*Day	2	0.24145833	0.12072917	12.22	<.0001
Day*Fat	1	0.06722222	0.06722222	6.81	0.0115

Table A-34. ANOVA table for the sensory after feeling factor astringent

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	11	1.92075617	0.17461420		
Error	60	2.51299383	0.04188323		
Corrected Total	71	4.43375000			
Rep	2	0.62120370	0.31060185	7.42	0.0013
Trt	5	0.16523148	0.03304630	0.79	0.5617
Day	1	0.14820988	0.14820988	3.54	0.0648
Fat	1	0.48895062	0.48895062	11.67	0.0011
Rep*Day	2	0.49716049	0.24858025	5.94	0.0044

Table A-35. ANOVA table for the sensory after feeling factor fat mouthfeel

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	9	8.57880787	0.95320087		
Error	62	4.54785494	0.07335250		
Corrected Total	71	13.12666281			
Rep	2	2.49169753	1.24584877	16.98	<.0001
Trt	5	1.11867670	0.22373534	3.05	0.0159
Day	1	0.06824460	0.06824460	0.93	0.3385
Fat	1	4.90018904	4.90018904	66.80	<.0001

Table A-36. ANOVA table for the sensory after feeling factor sorghum mouthfeel

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	9	4.78817758	0.53201973		
Error	56	8.93675929	0.15958499		
Corrected Total	65	13.72493687			
Rep	2	0.04952779	0.15958499	0.16	0.8566
Trt	5	2.45309553	0.49061911	3.07	0.0160
Day	1	0.07396798	0.07396798	0.46	0.4988
Fat	1	2.40524824	2.40524824	15.07	0.0003

Table A-37. ANOVA table for the sensory texture springiness

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	9	5.80844136	0.64538237		
Error	62	11.94919753	0.19272899		
Corrected Total	71	17.75763889			
Rep	2	0.09694444	0.04847222	0.25	0.7784
Trt	5	1.07370370	0.21474074	1.11	0.3622
Day	1	0.00347222	0.00347222	0.02	0.8937
Fat	1	4.63432099	4.63432099	24.05	<.0001

Table A-38. ANOVA table for the sensory texture hardness

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	9	5.16591049	0.57399005		
Error	62	6.05663194	0.09768761		
Corrected Total	71	11.22254244			
Rep	2	1.31935957	0.65967978	6.75	0.0022
Trt	5	0.78349151	0.15669830	1.60	0.1723
Day	1	0.10250386	0.10250386	1.05	0.3096
Fat	1	2.96055556	2.96055556	30.31	<.0001

Table A-39. ANOVA table for the sensory texture sandy/gritty

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	9	1.66051386	0.18450154		
Error	58	2.50451882	0.04318136		
Corrected Total	67	4.16503268			
Rep	2	0.11073303	0.05536652	1.28	0.2852
Trt	5	0.65287523	0.13057505	3.02	0.0171
Day	1	0.04882111	0.04882111	1.13	0.2921
Fat	1	0.77737085	0.77737085	18.00	<.0001

Table A-40. ANOVA table for the sensory texture juiciness

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	9	2.28350694	0.25372299		
Error	62	10.93840278	0.17642585		
Corrected Total	71	13.22190972			
Rep	2	0.78881944	0.39440972	2.24	0.1155
Trt	5	1.09295139	0.21859028	1.24	0.3019
Day	1	0.18503472	0.18503472	1.05	0.3098
Fat	1	0.21670139	0.21670139	1.23	0.2720

APPENDIX B

RAW DATA

Table B-1. Raw pH data table of the raw gound beef patties

Date	CON	Rep	Day	Trt	Fat	pH1	pH2	pH3
7/10/2005	RAW	1	0	CON	10	5.94	5.87	5.84
7/10/2005	RAW	1	0	BAT	10	6.13	6.01	5.9
7/10/2005	RAW	1	0	ROS	10	5.9	5.99	5.89
7/10/2005	RAW	1	0	LSM	10	6.02	5.98	5.98
7/10/2005	RAW	1	0	MSM	10	6.21	6.03	5.98
7/10/2005	RAW	1	0	HSM	10	6.51	6.22	6.22
7/10/2005	RAW	1	0	CON	27	6.39	6.11	6.08
7/10/2005	RAW	1	0	BAT	27	6.47	6.4	6.37
7/10/2005	RAW	1	0	ROS	27	6.31	6.31	6.3
7/10/2005	RAW	1	0	LSM	27	6.44	6.42	6.37
7/10/2005	RAW	1	0	MSM	27	6.28	6.24	6.21
7/10/2005	RAW	1	0	HSM	27	6.12	6.12	6.13
7/17/2005	RAW	2	0	CON	10	6.13	6.06	6.02
7/17/2005	RAW	2	0	BAT	10	5.99	5.98	5.98
7/17/2005	RAW	2	0	ROS	10	6.31	6.23	6.15
7/17/2005	RAW	2	0	LSM	10	6.36	6.25	6.15
7/17/2005	RAW	2	0	MSM	10	6.55	6.35	6.33
7/17/2005	RAW	2	0	HSM	10	6.53	6.37	6.24
7/17/2005	RAW	2	0	CON	27	6.66	6.48	6.42
7/17/2005	RAW	2	0	BAT	27	6.31	6.3	6.2
7/17/2005	RAW	2	0	ROS	27	6.19	6.18	6.18
7/17/2005	RAW	2	0	LSM	27	6.46	6.43	6.37
7/17/2005	RAW	2	0	MSM	27	6.29	6.31	6.33
7/17/2005	RAW	2	0	HSM	27	6.22	6.24	6.18
9/18/2005	RAW	3	0	CON	10	5.92	5.82	.
9/18/2005	RAW	3	0	BAT	10	5.85	5.76	.
9/18/2005	RAW	3	0	ROS	10	5.85	5.76	.
9/18/2005	RAW	3	0	LSM	10	5.75	5.73	.
9/18/2005	RAW	3	0	MSM	10	5.86	5.79	.
9/18/2005	RAW	3	0	HSM	10	5.85	5.81	.
9/18/2005	RAW	3	0	CON	27	6.3	6.25	.
9/18/2005	RAW	3	0	BAT	27	5.95	5.88	.
9/18/2005	RAW	3	0	ROS	27	5.96	5.89	.
9/18/2005	RAW	3	0	LSM	27	5.87	5.81	.
9/18/2005	RAW	3	0	MSM	27	5.76	5.78	.
9/18/2005	RAW	3	0	HSM	27	6.05	6.01	.

Table B-2. Raw L* (lightness) data table of the raw gound beef patties

Date	CON	Rep	Day	Trt	Fat	L*1	L*2	L*3
7/10/2005	RAW	1	0	CON	10	53.5	49.66	51.97
7/10/2005	RAW	1	0	BAT	10	53.22	52.6	52.08
7/10/2005	RAW	1	0	ROS	10	53.85	53.9	51.34
7/10/2005	RAW	1	0	LSM	10	51.3	51.86	50.53
7/10/2005	RAW	1	0	MSM	10	51.62	52.08	47.77
7/10/2005	RAW	1	0	HSM	10	49.3	47.31	48.28
7/10/2005	RAW	1	0	CON	27	55.42	56.21	55.12
7/10/2005	RAW	1	0	BAT	27	55.41	56.14	58.7
7/10/2005	RAW	1	0	ROS	27	56.41	57	54.4
7/10/2005	RAW	1	0	LSM	27	58.51	52.22	56.11
7/10/2005	RAW	1	0	MSM	27	56.93	52.86	52.47
7/10/2005	RAW	1	0	HSM	27	53.15	50.98	49.61
7/17/2005	RAW	2	0	CON	10	51.44	48.98	46.78
7/17/2005	RAW	2	0	BAT	10	49.96	48.83	47.06
7/17/2005	RAW	2	0	ROS	10	51.37	51.31	52.48
7/17/2005	RAW	2	0	LSM	10	50.61	51.41	51.12
7/17/2005	RAW	2	0	MSM	10	47.3	47.55	47.75
7/17/2005	RAW	2	0	HSM	10	46.3	47.28	48.84
7/17/2005	RAW	2	0	CON	27	57.96	55.96	57.63
7/17/2005	RAW	2	0	BAT	27	57.64	57.46	60.68
7/17/2005	RAW	2	0	ROS	27	57.89	58.82	55.19
7/17/2005	RAW	2	0	LSM	27	58.16	57.59	58.56
7/17/2005	RAW	2	0	MSM	27	56.38	54.89	55.25
7/17/2005	RAW	2	0	HSM	27	52.23	55.48	55.32
9/18/2005	RAW	3	0	CON	10	50.99	48.16	49.12
9/18/2005	RAW	3	0	BAT	10	49.38	50.87	49.82
9/18/2005	RAW	3	0	ROS	10	51.02	49.45	49.11
9/18/2005	RAW	3	0	LSM	10	50.13	47.76	46.12
9/18/2005	RAW	3	0	MSM	10	46.38	46.15	47.71
9/18/2005	RAW	3	0	HSM	10	45.95	45.5	42.31
9/18/2005	RAW	3	0	CON	27	57.76	57.51	55.55
9/18/2005	RAW	3	0	BAT	27	58.76	55.57	53.32
9/18/2005	RAW	3	0	ROS	27	56.61	55.76	55.95
9/18/2005	RAW	3	0	LSM	27	58.71	54.34	55.95
9/18/2005	RAW	3	0	MSM	27	53.79	52.3	54.4
9/18/2005	RAW	3	0	HSM	27	55.7	54.28	53.21

Table B-3. Raw a* (redness) data table of the raw gound beef patties

Date	CON	Rep	Day	Trt	Fat	a*1	a*2	a*3
7/10/2005	RAW	1	0	CON	10	16.02	17.02	17.18
7/10/2005	RAW	1	0	BAT	10	17	15.52	15.3
7/10/2005	RAW	1	0	ROS	10	17.05	15	18.78
7/10/2005	RAW	1	0	LSM	10	17.99	18.11	18.34
7/10/2005	RAW	1	0	MSM	10	15.91	14.44	16.62
7/10/2005	RAW	1	0	HSM	10	13.37	15.65	15.41
7/10/2005	RAW	1	0	CON	27	24.92	26.32	28.7
7/10/2005	RAW	1	0	BAT	27	25.49	26.04	23
7/10/2005	RAW	1	0	ROS	27	24.09	26.53	25.99
7/10/2005	RAW	1	0	LSM	27	22.13	24.91	22.59
7/10/2005	RAW	1	0	MSM	27	21.22	22.74	23.18
7/10/2005	RAW	1	0	HSM	27	18.68	20.03	18.53
7/17/2005	RAW	2	0	CON	10	15.2	17.09	18.39
7/17/2005	RAW	2	0	BAT	10	17.35	17.76	18.99
7/17/2005	RAW	2	0	ROS	10	16.88	15.63	15.85
7/17/2005	RAW	2	0	LSM	10	16.13	18.24	15.92
7/17/2005	RAW	2	0	MSM	10	16.35	17.8	17.7
7/17/2005	RAW	2	0	HSM	10	15.96	15.18	16.48
7/17/2005	RAW	2	0	CON	27	23.5	23.93	24.37
7/17/2005	RAW	2	0	BAT	27	23.61	22.85	24.28
7/17/2005	RAW	2	0	ROS	27	22.71	24.82	24.37
7/17/2005	RAW	2	0	LSM	27	18.66	21.74	22.49
7/17/2005	RAW	2	0	MSM	27	20.87	20.06	20.69
7/17/2005	RAW	2	0	HSM	27	19.68	20.84	18.87
9/18/2005	RAW	3	0	CON	10	13.91	15.72	15.73
9/18/2005	RAW	3	0	BAT	10	15.02	15.98	15.6
9/18/2005	RAW	3	0	ROS	10	14.68	16.92	15.63
9/18/2005	RAW	3	0	LSM	10	12.73	14.86	16.28
9/18/2005	RAW	3	0	MSM	10	15.34	15.76	14.68
9/18/2005	RAW	3	0	HSM	10	14.34	14.31	15.23
9/18/2005	RAW	3	0	CON	27	24.64	23.61	23.53
9/18/2005	RAW	3	0	BAT	27	22.41	25.55	23.79
9/18/2005	RAW	3	0	ROS	27	24.68	26.34	25.17
9/18/2005	RAW	3	0	LSM	27	20.58	24.59	23.78
9/18/2005	RAW	3	0	MSM	27	22.94	21.05	21.11
9/18/2005	RAW	3	0	HSM	27	19.21	18.39	19.9

Table B-4. Raw b* (yellowness) data table of the raw gound beef patties

Date	CON	Rep	Day	Trt	Fat	b*1	b*2	b*3
7/10/2005	RAW	1	0	CON	10	10.06	10.71	10.13
7/10/2005	RAW	1	0	BAT	10	10.66	8.54	9.38
7/10/2005	RAW	1	0	ROS	10	9.78	8.84	11.38
7/10/2005	RAW	1	0	LSM	10	10.79	10.59	10.73
7/10/2005	RAW	1	0	MSM	10	11.39	9.35	10.69
7/10/2005	RAW	1	0	HSM	10	8.1	9.38	10.16
7/10/2005	RAW	1	0	CON	27	12.21	14.14	15.3
7/10/2005	RAW	1	0	BAT	27	14.25	14.03	12.58
7/10/2005	RAW	1	0	ROS	27	13.62	12.78	14.26
7/10/2005	RAW	1	0	LSM	27	13.61	12.68	12.19
7/10/2005	RAW	1	0	MSM	27	12.34	11.99	12.8
7/10/2005	RAW	1	0	HSM	27	10.49	11.61	10.97
7/17/2005	RAW	2	0	CON	10	8.58	9.58	10.79
7/17/2005	RAW	2	0	BAT	10	9.45	9.39	10.25
7/17/2005	RAW	2	0	ROS	10	9.61	9.11	10.47
7/17/2005	RAW	2	0	LSM	10	10.43	11.11	9.36
7/17/2005	RAW	2	0	MSM	10	9.73	9.44	10.4
7/17/2005	RAW	2	0	HSM	10	9.48	9.04	10.13
7/17/2005	RAW	2	0	CON	27	13.44	13.78	14.2
7/17/2005	RAW	2	0	BAT	27	13.92	12.87	14.94
7/17/2005	RAW	2	0	ROS	27	12.74	14.72	13.88
7/17/2005	RAW	2	0	LSM	27	10.46	13.37	14.1
7/17/2005	RAW	2	0	MSM	27	12.47	11.24	11.95
7/17/2005	RAW	2	0	HSM	27	11.86	13.82	11.68
9/18/2005	RAW	3	0	CON	10	7.54	8.97	8.97
9/18/2005	RAW	3	0	BAT	10	8.33	8.77	8.57
9/18/2005	RAW	3	0	ROS	10	7.8	10.28	8.63
9/18/2005	RAW	3	0	LSM	10	6.97	8.34	9.36
9/18/2005	RAW	3	0	MSM	10	9.2	9.28	9.21
9/18/2005	RAW	3	0	HSM	10	8.7	8.9	8.84
9/18/2005	RAW	3	0	CON	27	13.29	12.92	12.08
9/18/2005	RAW	3	0	BAT	27	12.76	12.42	11.6
9/18/2005	RAW	3	0	ROS	27	13.61	14.45	13.23
9/18/2005	RAW	3	0	LSM	27	12.34	12.7	13.04
9/18/2005	RAW	3	0	MSM	27	13.09	11.36	11.76
9/18/2005	RAW	3	0	HSM	27	11.57	11.4	12.34

Table B-5. Raw fat and moisture concentration data table of the raw gound beef patties

Date	CON	Rep	Day	Fat	Fat Con %	Moisture %
7/9/2005	RAW	1	0	10	8.4	71
7/9/2005	RAW	1	0	10	8.37	71.1
7/9/2005	RAW	1	0	10	8.44	70.97
7/9/2005	RAW	1	0	27	23.76	58.82
7/9/2005	RAW	1	0	27	23.18	59.24
7/9/2005	RAW	1	0	27	22.89	59.46
7/16/2005	RAW	2	0	10	9.06	70.5
7/16/2005	RAW	2	0	10	9.14	70.41
7/16/2005	RAW	2	0	27	24.85	58.09
7/16/2005	RAW	2	0	27	25.28	57.68
9/21/2005	RAW	3	0	10	4.74	74.03
9/21/2005	RAW	3	0	10	4.71	74.14
9/21/2005	RAW	3	0	27	23.4	59.47
9/21/2005	RAW	3	0	27	22.14	60.45

Table B-6. Raw raw and cooked weight data table of the gound beef patties

Date	CON	Rep	Day	Trt	Fat	R Wt.	C Wt1	C Wt2
7/10/2005	COOKED	1	0	CON	10	200	148.8	157.8
7/10/2005	COOKED	1	0	BAT	10	200	155.5	155.9
7/10/2005	COOKED	1	0	ROS	10	200	153.4	146.2
7/10/2005	COOKED	1	0	LSM	10	200	149.5	154.2
7/10/2005	COOKED	1	0	MSM	10	200	162.7	150.6
7/10/2005	COOKED	1	0	HSM	10	200	172.2	161
7/10/2005	COOKED	1	0	CON	27	200	145.9	144.2
7/10/2005	COOKED	1	0	BAT	27	200	138.6	127.8
7/10/2005	COOKED	1	0	ROS	27	200	128.6	131.4
7/10/2005	COOKED	1	0	LSM	27	200	132.7	125.2
7/10/2005	COOKED	1	0	MSM	27	200	128.5	135.8
7/10/2005	COOKED	1	0	HSM	27	200	132.4	135.5
7/11/2005	COOKED	1	1	CON	10	200	158.7	153.2
7/11/2005	COOKED	1	1	BAT	10	200	155.2	163.7
7/11/2005	COOKED	1	1	ROS	10	200	145.5	161.3
7/11/2005	COOKED	1	1	LSM	10	200	151.9	162.3
7/11/2005	COOKED	1	1	MSM	10	200	157.3	148.3
7/11/2005	COOKED	1	1	HSM	10	200	151.1	159
7/11/2005	COOKED	1	1	CON	27	200	120.3	127.7
7/11/2005	COOKED	1	1	BAT	27	200	133	124.9
7/11/2005	COOKED	1	1	ROS	27	200	121	133.2
7/11/2005	COOKED	1	1	LSM	27	200	124.3	129.1
7/11/2005	COOKED	1	1	MSM	27	200	129.3	123.5
7/11/2005	COOKED	1	1	HSM	27	200	134.7	137.9
7/13/2005	COOKED	1	3	CON	10	200	149.4	154.2
7/13/2005	COOKED	1	3	BAT	10	200	145.9	132.9
7/13/2005	COOKED	1	3	ROS	10	200	151.4	153.8
7/13/2005	COOKED	1	3	LSM	10	200	151.6	159
7/13/2005	COOKED	1	3	MSM	10	200	141.9	147.5
7/13/2005	COOKED	1	3	HSM	10	200	148.3	163.4
7/13/2005	COOKED	1	3	CON	27	200	130.5	128.1
7/13/2005	COOKED	1	3	BAT	27	200	120	119
7/13/2005	COOKED	1	3	ROS	27	200	122.3	123.7
7/13/2005	COOKED	1	3	LSM	27	200	125.9	132.2
7/13/2005	COOKED	1	3	MSM	27	200	136.3	125.1
7/13/2005	COOKED	1	3	HSM	27	200	130.4	126
7/15/2005	COOKED	1	5	CON	10	200	150.1	160.2
7/15/2005	COOKED	1	5	BAT	10	200	148.6	160.9

Table B-6. Continued

Date	CON	Rep	Day	Trt	Fat	R Wt.	C Wt1	C Wt2
7/15/2005	COOKED	1	5	ROS	10	200	149.8	155.1
7/15/2005	COOKED	1	5	LSM	10	200	154.7	150.9
7/15/2005	COOKED	1	5	MSM	10	200	163.4	140
7/15/2005	COOKED	1	5	HSM	10	200	164.3	154.7
7/15/2005	COOKED	1	5	CON	27	200	122	134.3
7/15/2005	COOKED	1	5	BAT	27	200	124	121.3
7/15/2005	COOKED	1	5	ROS	27	200	130.2	139.7
7/15/2005	COOKED	1	5	LSM	27	200	124.3	116.6
7/15/2005	COOKED	1	5	MSM	27	200	126.8	129.9
7/15/2005	COOKED	1	5	HSM	27	200	132	124.1
7/17/2005	COOKED	2	0	CON	10	200	155.2	154.3
7/17/2005	COOKED	2	0	BAT	10	200	158.9	151.2
7/17/2005	COOKED	2	0	ROS	10	200	153.9	151.5
7/17/2005	COOKED	2	0	LSM	10	200	155.8	158
7/17/2005	COOKED	2	0	MSM	10	200	154.5	159.3
7/17/2005	COOKED	2	0	HSM	10	200	158.5	158.9
7/17/2005	COOKED	2	0	CON	27	200	135.8	137.4
7/17/2005	COOKED	2	0	BAT	27	200	118.2	123
7/17/2005	COOKED	2	0	ROS	27	200	.	.
7/17/2005	COOKED	2	0	LSM	27	200	132.3	128.2
7/17/2005	COOKED	2	0	MSM	27	200	112.6	121.5
7/17/2005	COOKED	2	0	HSM	27	200	120.7	124.9
7/18/2005	COOKED	2	1	CON	10	200	154.7	159.4
7/18/2005	COOKED	2	1	BAT	10	200	164.4	160.7
7/18/2005	COOKED	2	1	ROS	10	200	158.2	155.2
7/18/2005	COOKED	2	1	LSM	10	200	153.7	142.6
7/18/2005	COOKED	2	1	MSM	10	200	168.3	151.7
7/18/2005	COOKED	2	1	HSM	10	200	164.7	165.5
7/18/2005	COOKED	2	1	CON	27	200	133.2	125.6
7/18/2005	COOKED	2	1	BAT	27	200	129.3	119.2
7/18/2005	COOKED	2	1	ROS	27	200	.	.
7/18/2005	COOKED	2	1	LSM	27	200	130.9	117.7
7/18/2005	COOKED	2	1	MSM	27	200	117.7	118.9
7/18/2005	COOKED	2	1	HSM	27	200	124.9	124.6
7/20/2005	COOKED	2	3	CON	10	200	151.2	153.3
7/20/2005	COOKED	2	3	BAT	10	200	153.8	154.1
7/20/2005	COOKED	2	3	ROS	10	200	146.9	162.2
7/20/2005	COOKED	2	3	LSM	10	200	147.2	151.4

Table B-6. Continued

Date	CON	Rep	Day	Trt	Fat	R Wt.	C Wt1	C Wt2
7/20/2005	COOKED	2	3	MSM	10	200	162.5	163
7/20/2005	COOKED	2	3	HSM	10	200	167.3	163.9
7/20/2005	COOKED	2	3	CON	27	200	114.4	132.5
7/20/2005	COOKED	2	3	BAT	27	200	160.1	129.4
7/20/2005	COOKED	2	3	ROS	27	200	.	.
7/20/2005	COOKED	2	3	LSM	27	200	118.9	125.7
7/20/2005	COOKED	2	3	MSM	27	200	127.2	132.6
7/20/2005	COOKED	2	3	HSM	27	200	133.7	132.2
7/22/2005	COOKED	2	5	CON	10	200	155.7	144.5
7/22/2005	COOKED	2	5	BAT	10	200	140.6	157.4
7/22/2005	COOKED	2	5	ROS	10	200	151.2	144.2
7/22/2005	COOKED	2	5	LSM	10	200	150.8	153.7
7/22/2005	COOKED	2	5	MSM	10	200	160.3	147.1
7/22/2005	COOKED	2	5	HSM	10	200	152.3	156.3
7/22/2005	COOKED	2	5	CON	27	200	124.9	113.7
7/22/2005	COOKED	2	5	BAT	27	200	127.6	127.4
7/22/2005	COOKED	2	5	ROS	27	200	.	.
7/22/2005	COOKED	2	5	LSM	27	200	126.9	113.8
7/22/2005	COOKED	2	5	MSM	27	200	117.5	118.7
7/22/2005	COOKED	2	5	HSM	27	200	129.4	127.8
9/18/2005	COOKED	3	0	CON	10	200	168.8	163.1
9/18/2005	COOKED	3	0	BAT	10	200	152.2	157.9
9/18/2005	COOKED	3	0	ROS	10	200	142.2	147.9
9/18/2005	COOKED	3	0	LSM	10	200	157.7	154
9/18/2005	COOKED	3	0	MSM	10	200	155.8	156
9/18/2005	COOKED	3	0	HSM	10	200	164	165.6
9/18/2005	COOKED	3	0	CON	27	200	127.9	118.3
9/18/2005	COOKED	3	0	BAT	27	200	117.6	113.2
9/18/2005	COOKED	3	0	ROS	27	200	133.4	124.8
9/18/2005	COOKED	3	0	LSM	27	200	126	130
9/18/2005	COOKED	3	0	MSM	27	200	116.5	125.5
9/18/2005	COOKED	3	0	HSM	27	200	115.7	114.6
9/19/2005	COOKED	3	1	CON	10	200	167.5	165
9/19/2005	COOKED	3	1	BAT	10	200	159.8	153.2
9/19/2005	COOKED	3	1	ROS	10	200	150.1	149.7
9/19/2005	COOKED	3	1	LSM	10	200	153.6	161.1
9/19/2005	COOKED	3	1	MSM	10	200	159.6	151.2
9/19/2005	COOKED	3	1	HSM	10	200	164.9	161.4

Table B-6. Continued

Date	CON	Rep	Day	Trt	Fat	R Wt.	C Wt1	C Wt2
9/19/2005	COOKED	3	1	CON	27	200	127.9	125.3
9/19/2005	COOKED	3	1	BAT	27	200	119.6	112.3
9/19/2005	COOKED	3	1	ROS	27	200	125.2	117.7
9/19/2005	COOKED	3	1	LSM	27	200	134.2	121.8
9/19/2005	COOKED	3	1	MSM	27	200	124.7	121.9
9/19/2005	COOKED	3	1	HSM	27	200	127.3	128.1
9/21/2005	COOKED	3	3	CON	10	200	165.3	154.5
9/21/2005	COOKED	3	3	BAT	10	200	150.7	155.4
9/21/2005	COOKED	3	3	ROS	10	200	161.3	160.6
9/21/2005	COOKED	3	3	LSM	10	200	147.6	154.8
9/21/2005	COOKED	3	3	MSM	10	200	146.3	154.2
9/21/2005	COOKED	3	3	HSM	10	200	167.9	162
9/21/2005	COOKED	3	3	CON	27	200	128.2	111.1
9/21/2005	COOKED	3	3	BAT	27	200	110.3	113.8
9/21/2005	COOKED	3	3	ROS	27	200	124.6	122.6
9/21/2005	COOKED	3	3	LSM	27	200	129.1	120.6
9/21/2005	COOKED	3	3	MSM	27	200	126.3	122.3
9/21/2005	COOKED	3	3	HSM	27	200	131.6	124.7
9/29/2005	COOKED	3	5	CON	10	200	157.9	161.5
9/29/2005	COOKED	3	5	BAT	10	200	152.4	154.6
9/29/2005	COOKED	3	5	ROS	10	200	160	153.4
9/29/2005	COOKED	3	5	LSM	10	200	151.1	151.2
9/29/2005	COOKED	3	5	MSM	10	200	152.4	150
9/29/2005	COOKED	3	5	HSM	10	200	160.2	156.6
9/29/2005	COOKED	3	5	CON	27	200	122.6	113.2
9/29/2005	COOKED	3	5	BAT	27	200	106.7	103.9
9/29/2005	COOKED	3	5	ROS	27	200	123.1	106.7
9/29/2005	COOKED	3	5	LSM	27	200	134.5	134.4
9/29/2005	COOKED	3	5	MSM	27	200	135.2	121.5
9/29/2005	COOKED	3	5	HSM	27	200	126.5	126.2

Table B-7. Raw cook time data table of the gound beef patties

Date	CON	Rep	Day	Trt	Fat	T OFF 1	T OFF 2
7/10/2005	COOKED	1	0	CON	10	75	73
7/10/2005	COOKED	1	0	BAT	10	73	77
7/10/2005	COOKED	1	0	ROS	10	74	75
7/10/2005	COOKED	1	0	LSM	10	74	74
7/10/2005	COOKED	1	0	MSM	10	73	73
7/10/2005	COOKED	1	0	HSM	10	73	73
7/10/2005	COOKED	1	0	CON	27	73	73
7/10/2005	COOKED	1	0	BAT	27	73	73
7/10/2005	COOKED	1	0	ROS	27	73	73
7/10/2005	COOKED	1	0	LSM	27	73	73
7/10/2005	COOKED	1	0	MSM	27	73	73
7/10/2005	COOKED	1	0	HSM	27	73	73
7/11/2005	COOKED	1	1	CON	10	73	74
7/11/2005	COOKED	1	1	BAT	10	73	73
7/11/2005	COOKED	1	1	ROS	10	73	73
7/11/2005	COOKED	1	1	LSM	10	75	74
7/11/2005	COOKED	1	1	MSM	10	73	73
7/11/2005	COOKED	1	1	HSM	10	73	74
7/11/2005	COOKED	1	1	CON	27	73	73
7/11/2005	COOKED	1	1	BAT	27	73	73
7/11/2005	COOKED	1	1	ROS	27	73	73
7/11/2005	COOKED	1	1	LSM	27	73	73
7/11/2005	COOKED	1	1	MSM	27	73	73
7/11/2005	COOKED	1	1	HSM	27	73	73
7/13/2005	COOKED	1	3	CON	10	73	73
7/13/2005	COOKED	1	3	BAT	10	85	73
7/13/2005	COOKED	1	3	ROS	10	73	73
7/13/2005	COOKED	1	3	LSM	10	73	74
7/13/2005	COOKED	1	3	MSM	10	77.6	73
7/13/2005	COOKED	1	3	HSM	10	73	73
7/13/2005	COOKED	1	3	CON	27	73	73
7/13/2005	COOKED	1	3	BAT	27	73	73
7/13/2005	COOKED	1	3	ROS	27	73	73
7/13/2005	COOKED	1	3	LSM	27	73	73
7/13/2005	COOKED	1	3	MSM	27	74	74
7/13/2005	COOKED	1	3	HSM	27	74	74
7/15/2005	COOKED	1	5	CON	10	73	82
7/15/2005	COOKED	1	5	BAT	10	73	73

Table B-7. Continued

Date	CON	Rep	Day	Trt	Fat	T OFF 1	T OFF 2
7/15/2005	COOKED	1	5	ROS	10	81	73
7/15/2005	COOKED	1	5	LSM	10	73	78
7/15/2005	COOKED	1	5	MSM	10	76	73
7/15/2005	COOKED	1	5	HSM	10	73	74
7/15/2005	COOKED	1	5	CON	27	73	73
7/15/2005	COOKED	1	5	BAT	27	73	73
7/15/2005	COOKED	1	5	ROS	27	73	74
7/15/2005	COOKED	1	5	LSM	27	74	76
7/15/2005	COOKED	1	5	MSM	27	73	73
7/15/2005	COOKED	1	5	HSM	27	73	75
7/17/2005	COOKED	2	0	CON	10	73	73
7/17/2005	COOKED	2	0	BAT	10	73	73
7/17/2005	COOKED	2	0	ROS	10	73	73
7/17/2005	COOKED	2	0	LSM	10	73	73
7/17/2005	COOKED	2	0	MSM	10	73	73
7/17/2005	COOKED	2	0	HSM	10	73	73
7/17/2005	COOKED	2	0	CON	27	74	73
7/17/2005	COOKED	2	0	BAT	27	73	73
7/17/2005	COOKED	2	0	ROS	27	73	73
7/17/2005	COOKED	2	0	LSM	27	73	74
7/17/2005	COOKED	2	0	MSM	27	73	73
7/17/2005	COOKED	2	0	HSM	27	73	73
7/18/2005	COOKED	2	1	CON	10	73	73
7/18/2005	COOKED	2	1	BAT	10	73	73
7/18/2005	COOKED	2	1	ROS	10	73	73
7/18/2005	COOKED	2	1	LSM	10	73	73
7/18/2005	COOKED	2	1	MSM	10	73	75
7/18/2005	COOKED	2	1	HSM	10	73	73
7/18/2005	COOKED	2	1	CON	27	73	73
7/18/2005	COOKED	2	1	BAT	27	73	73
7/18/2005	COOKED	2	1	ROS	27	73	73
7/18/2005	COOKED	2	1	LSM	27	73	73
7/18/2005	COOKED	2	1	MSM	27	73	73
7/18/2005	COOKED	2	1	HSM	27	73	73
7/20/2005	COOKED	2	3	CON	10	73	73
7/20/2005	COOKED	2	3	BAT	10	73	74
7/20/2005	COOKED	2	3	ROS	10	73	73
7/20/2005	COOKED	2	3	LSM	10	73	73

Table B-7. Continued

Date	CON	Rep	Day	Trt	Fat	T OFF 1	T OFF 2
7/20/2005	COOKED	2	3	MSM	10	73	73
7/20/2005	COOKED	2	3	HSM	10	73	73
7/20/2005	COOKED	2	3	CON	27	73	73
7/20/2005	COOKED	2	3	BAT	27	75	75
7/20/2005	COOKED	2	3	ROS	27	74	76
7/20/2005	COOKED	2	3	LSM	27	73	73
7/20/2005	COOKED	2	3	MSM	27	73	73
7/20/2005	COOKED	2	3	HSM	27	73	73
7/22/2005	COOKED	2	5	CON	10	73	73
7/22/2005	COOKED	2	5	BAT	10	75	73
7/22/2005	COOKED	2	5	ROS	10	73	73
7/22/2005	COOKED	2	5	LSM	10	73	74
7/22/2005	COOKED	2	5	MSM	10	73	73
7/22/2005	COOKED	2	5	HSM	10	73	73
7/22/2005	COOKED	2	5	CON	27	73	73
7/22/2005	COOKED	2	5	BAT	27	73	73
7/22/2005	COOKED	2	5	ROS	27	73	74
7/22/2005	COOKED	2	5	LSM	27	73	73
7/22/2005	COOKED	2	5	MSM	27	73	73
7/22/2005	COOKED	2	5	HSM	27	73	73
9/18/2005	COOKED	3	0	CON	10	73	73.1
9/18/2005	COOKED	3	0	BAT	10	75	73.5
9/18/2005	COOKED	3	0	ROS	10	73.8	73.4
9/18/2005	COOKED	3	0	LSM	10	73	73.7
9/18/2005	COOKED	3	0	MSM	10	73	73
9/18/2005	COOKED	3	0	HSM	10	70.1	70
9/18/2005	COOKED	3	0	CON	27	73	73
9/18/2005	COOKED	3	0	BAT	27	73.3	73.2
9/18/2005	COOKED	3	0	ROS	27	73.1	73.5
9/18/2005	COOKED	3	0	LSM	27	72.8	73
9/18/2005	COOKED	3	0	MSM	27	73	73.1
9/18/2005	COOKED	3	0	HSM	27	73	73.9
9/19/2005	COOKED	3	1	CON	10	76	74
9/19/2005	COOKED	3	1	BAT	10	73	74
9/19/2005	COOKED	3	1	ROS	10	76.2	75
9/19/2005	COOKED	3	1	LSM	10	73.2	73.5
9/19/2005	COOKED	3	1	MSM	10	73.5	73.2
9/19/2005	COOKED	3	1	HSM	10	70	70

Table B-7. Continued

Date	CON	Rep	Day	Trt	Fat	T OFF 1	T OFF 2
9/19/2005	COOKED	3	1	CON	27	73.8	74
9/19/2005	COOKED	3	1	BAT	27	74	73.1
9/19/2005	COOKED	3	1	ROS	27	73	73.4
9/19/2005	COOKED	3	1	LSM	27	73.3	73.2
9/19/2005	COOKED	3	1	MSM	27	74	73.4
9/19/2005	COOKED	3	1	HSM	27	73.6	74
9/21/2005	COOKED	3	3	CON	10	73	73
9/21/2005	COOKED	3	3	BAT	10	76	74
9/21/2005	COOKED	3	3	ROS	10	73	73.4
9/21/2005	COOKED	3	3	LSM	10	77.5	73
9/21/2005	COOKED	3	3	MSM	10	76	73
9/21/2005	COOKED	3	3	HSM	10	70.5	71
9/21/2005	COOKED	3	3	CON	27	73.1	73.8
9/21/2005	COOKED	3	3	BAT	27	73.3	73.7
9/21/2005	COOKED	3	3	ROS	27	73.8	73.1
9/21/2005	COOKED	3	3	LSM	27	73	74.8
9/21/2005	COOKED	3	3	MSM	27	74.3	73
9/21/2005	COOKED	3	3	HSM	27	74	73.4
9/29/2005	COOKED	3	5	CON	10	75	73
9/29/2005	COOKED	3	5	BAT	10	73	74
9/29/2005	COOKED	3	5	ROS	10	74	77.3
9/29/2005	COOKED	3	5	LSM	10	73.5	73
9/29/2005	COOKED	3	5	MSM	10	72.1	73.8
9/29/2005	COOKED	3	5	HSM	10	73	71.2
9/29/2005	COOKED	3	5	CON	27	74	74.6
9/29/2005	COOKED	3	5	BAT	27	73.5	73
9/29/2005	COOKED	3	5	ROS	27	73	74.8
9/29/2005	COOKED	3	5	LSM	27	76	73.2
9/29/2005	COOKED	3	5	MSM	27	74	75.3
9/29/2005	COOKED	3	5	HSM	27	73.6	73

Table B-8. Raw cook starting temperature data table of the gound beef patties

Date	CON	Rep	Day	Trt	Fat	T ON1	T ON 2
7/10/2005	COOKED	1	0	CON	10	843	843
7/10/2005	COOKED	1	0	BAT	10	912	912
7/10/2005	COOKED	1	0	ROS	10	940	940
7/10/2005	COOKED	1	0	LSM	10	1005	1005
7/10/2005	COOKED	1	0	MSM	10	1032	1032
7/10/2005	COOKED	1	0	HSM	10	1057	1057
7/10/2005	COOKED	1	0	CON	27	1122	1122
7/10/2005	COOKED	1	0	BAT	27	1145	1145
7/10/2005	COOKED	1	0	ROS	27	1210	1210
7/10/2005	COOKED	1	0	LSM	27	1238	1238
7/10/2005	COOKED	1	0	MSM	27	1308	1308
7/10/2005	COOKED	1	0	HSM	27	1337	1337
7/11/2005	COOKED	1	1	CON	10	843	843
7/11/2005	COOKED	1	1	BAT	10	912	912
7/11/2005	COOKED	1	1	ROS	10	940	940
7/11/2005	COOKED	1	1	LSM	10	1005	1005
7/11/2005	COOKED	1	1	MSM	10	1032	1033
7/11/2005	COOKED	1	1	HSM	10	1057	1057
7/11/2005	COOKED	1	1	CON	27	1122	1122
7/11/2005	COOKED	1	1	BAT	27	1145	1145
7/11/2005	COOKED	1	1	ROS	27	1210	1210
7/11/2005	COOKED	1	1	LSM	27	1238	1238
7/11/2005	COOKED	1	1	MSM	27	1308	1308
7/11/2005	COOKED	1	1	HSM	27	1337	1337
7/13/2005	COOKED	1	3	CON	10	843	843
7/13/2005	COOKED	1	3	BAT	10	914	914
7/13/2005	COOKED	1	3	ROS	10	942	942
7/13/2005	COOKED	1	3	LSM	10	1009	1009
7/13/2005	COOKED	1	3	MSM	10	1036	1036
7/13/2005	COOKED	1	3	HSM	10	1102	1102
7/13/2005	COOKED	1	3	CON	27	1126	1126
7/13/2005	COOKED	1	3	BAT	27	1150	1150
7/13/2005	COOKED	1	3	ROS	27	1218	1218
7/13/2005	COOKED	1	3	LSM	27	1245	1245
7/13/2005	COOKED	1	3	MSM	27	1315	1315
7/13/2005	COOKED	1	3	HSM	27	1341	1341
7/15/2005	COOKED	1	5	CON	10	843	843
7/15/2005	COOKED	1	5	BAT	10	914	914

Table B-8. Continued

Date	CON	Rep	Day	Trt	Fat	T ON1	T ON 2
7/15/2005	COOKED	1	5	ROS	10	942	942
7/15/2005	COOKED	1	5	LSM	10	1009	1009
7/15/2005	COOKED	1	5	MSM	10	1036	1036
7/15/2005	COOKED	1	5	HSM	10	1102	1102
7/15/2005	COOKED	1	5	CON	27	1126	1126
7/15/2005	COOKED	1	5	BAT	27	1150	1150
7/15/2005	COOKED	1	5	ROS	27	1218	1218
7/15/2005	COOKED	1	5	LSM	27	1245	1245
7/15/2005	COOKED	1	5	MSM	27	1315	1315
7/15/2005	COOKED	1	5	HSM	27	1341	1341
7/17/2005	COOKED	2	0	CON	10	818	818
7/17/2005	COOKED	2	0	BAT	10	843	843
7/17/2005	COOKED	2	0	ROS	10	903	903
7/17/2005	COOKED	2	0	LSM	10	923	923
7/17/2005	COOKED	2	0	MSM	10	943	943
7/17/2005	COOKED	2	0	HSM	10	1004	1004
7/17/2005	COOKED	2	0	CON	27	1025	1025
7/17/2005	COOKED	2	0	BAT	27	1041	1041
7/17/2005	COOKED	2	0	ROS	27	1110	1110
7/17/2005	COOKED	2	0	LSM	27	1134	1134
7/17/2005	COOKED	2	0	MSM	27	1200	1200
7/17/2005	COOKED	2	0	HSM	27	1218	1218
7/18/2005	COOKED	2	1	CON	10	818	818
7/18/2005	COOKED	2	1	BAT	10	843	843
7/18/2005	COOKED	2	1	ROS	10	903	903
7/18/2005	COOKED	2	1	LSM	10	923	923
7/18/2005	COOKED	2	1	MSM	10	943	943
7/18/2005	COOKED	2	1	HSM	10	1004	1004
7/18/2005	COOKED	2	1	CON	27	1025	1025
7/18/2005	COOKED	2	1	BAT	27	1041	1041
7/18/2005	COOKED	2	1	ROS	27	1110	1110
7/18/2005	COOKED	2	1	LSM	27	1134	1134
7/18/2005	COOKED	2	1	MSM	27	1200	1200
7/18/2005	COOKED	2	1	HSM	27	1218	1218
7/20/2005	COOKED	2	3	CON	10	820	820
7/20/2005	COOKED	2	3	BAT	10	843	843
7/20/2005	COOKED	2	3	ROS	10	906	906
7/20/2005	COOKED	2	3	LSM	10	924	924

Table B-8. Continued

Date	CON	Rep	Day	Trt	Fat	T ON1	T ON 2
7/20/2005	COOKED	2	3	MSM	10	945	945
7/20/2005	COOKED	2	3	HSM	10	1006	1006
7/20/2005	COOKED	2	3	CON	27	1027	1027
7/20/2005	COOKED	2	3	BAT	27	1044	1044
7/20/2005	COOKED	2	3	ROS	27	1112	1112
7/20/2005	COOKED	2	3	LSM	27	1136	1136
7/20/2005	COOKED	2	3	MSM	27	1157	1157
7/20/2005	COOKED	2	3	HSM	27	1228	1228
7/22/2005	COOKED	2	5	CON	10	820	820
7/22/2005	COOKED	2	5	BAT	10	843	843
7/22/2005	COOKED	2	5	ROS	10	906	906
7/22/2005	COOKED	2	5	LSM	10	924	924
7/22/2005	COOKED	2	5	MSM	10	945	945
7/22/2005	COOKED	2	5	HSM	10	1006	1006
7/22/2005	COOKED	2	5	CON	27	1027	1027
7/22/2005	COOKED	2	5	BAT	27	1044	1044
7/22/2005	COOKED	2	5	ROS	27	1112	1112
7/22/2005	COOKED	2	5	LSM	27	1136	1136
7/22/2005	COOKED	2	5	MSM	27	1157	1157
7/22/2005	COOKED	2	5	HSM	27	1228	1228
9/18/2005	COOKED	3	0	CON	10	802	802
9/18/2005	COOKED	3	0	BAT	10	826	826
9/18/2005	COOKED	3	0	ROS	10	850	850
9/18/2005	COOKED	3	0	LSM	10	914	914
9/18/2005	COOKED	3	0	MSM	10	938	938
9/18/2005	COOKED	3	0	HSM	10	738	738
9/18/2005	COOKED	3	0	CON	27	1130	1130
9/18/2005	COOKED	3	0	BAT	27	1001	1001
9/18/2005	COOKED	3	0	ROS	27	1050	1050
9/18/2005	COOKED	3	0	LSM	27	1026	1026
9/18/2005	COOKED	3	0	MSM	27	1109	1109
9/18/2005	COOKED	3	0	HSM	27	1151	1151
9/19/2005	COOKED	3	1	CON	10	802	802
9/19/2005	COOKED	3	1	BAT	10	826	826
9/19/2005	COOKED	3	1	ROS	10	850	850
9/19/2005	COOKED	3	1	LSM	10	914	914
9/19/2005	COOKED	3	1	MSM	10	938	938
9/19/2005	COOKED	3	1	HSM	10	738	738

Table B-8. Continued

Date	CON	Rep	Day	Trt	Fat	T ON1	T ON 2
9/19/2005	COOKED	3	1	CON	27	1130	1130
9/19/2005	COOKED	3	1	BAT	27	1001	1001
9/19/2005	COOKED	3	1	ROS	27	1050	1050
9/19/2005	COOKED	3	1	LSM	27	1026	1026
9/19/2005	COOKED	3	1	MSM	27	1109	1109
9/19/2005	COOKED	3	1	HSM	27	1151	1151
9/21/2005	COOKED	3	3	CON	10	808	808
9/21/2005	COOKED	3	3	BAT	10	831	831
9/21/2005	COOKED	3	3	ROS	10	852	852
9/21/2005	COOKED	3	3	LSM	10	917	917
9/21/2005	COOKED	3	3	MSM	10	941	941
9/21/2005	COOKED	3	3	HSM	10	740	740
9/21/2005	COOKED	3	3	CON	27	1135	1135
9/21/2005	COOKED	3	3	BAT	27	1004	1004

Table B-9. Raw cook ending temperature data table of the gound beef patties

Date	CON	Rep	Day	Trt	Fat	T OFF1	T OFF2
7/10/2005	COOKED	1	0	CON	10	857	850
7/10/2005	COOKED	1	0	BAT	10	924	926
7/10/2005	COOKED	1	0	ROS	10	954	959
7/10/2005	COOKED	1	0	LSM	10	1019	1020
7/10/2005	COOKED	1	0	MSM	10	1048	1048
7/10/2005	COOKED	1	0	HSM	10	1107	1112
7/10/2005	COOKED	1	0	CON	27	1132	1132
7/10/2005	COOKED	1	0	BAT	27	1159	1201
7/10/2005	COOKED	1	0	ROS	27	1228	1228
7/10/2005	COOKED	1	0	LSM	27	1256	1257
7/10/2005	COOKED	1	0	MSM	27	1325	1325
7/10/2005	COOKED	1	0	HSM	27	1352	1352
7/11/2005	COOKED	1	1	CON	10	852	852
7/11/2005	COOKED	1	1	BAT	10	926	923
7/11/2005	COOKED	1	1	ROS	10	957	956
7/11/2005	COOKED	1	1	LSM	10	1019	1019
7/11/2005	COOKED	1	1	MSM	10	1048	1047
7/11/2005	COOKED	1	1	HSM	10	1112	1108
7/11/2005	COOKED	1	1	CON	27	1140	1137
7/11/2005	COOKED	1	1	BAT	27	1202	1201
7/11/2005	COOKED	1	1	ROS	27	1231	1223
7/11/2005	COOKED	1	1	LSM	27	1300	1256
7/11/2005	COOKED	1	1	MSM	27	1324	1324
7/11/2005	COOKED	1	1	HSM	27	1353	1353
7/13/2005	COOKED	1	3	CON	10	859	900
7/13/2005	COOKED	1	3	BAT	10	927	933
7/13/2005	COOKED	1	3	ROS	10	955	955
7/13/2005	COOKED	1	3	LSM	10	1021	1027
7/13/2005	COOKED	1	3	MSM	10	1050	1053
7/13/2005	COOKED	1	3	HSM	10	1119	1114
7/13/2005	COOKED	1	3	CON	27	1142	1142
7/13/2005	COOKED	1	3	BAT	27	1208	1208
7/13/2005	COOKED	1	3	ROS	27	1234	1234
7/13/2005	COOKED	1	3	LSM	27	1302	1302
7/13/2005	COOKED	1	3	MSM	27	1329	1329
7/13/2005	COOKED	1	3	HSM	27	1356	1356
7/15/2005	COOKED	1	5	CON	10	856	854
7/15/2005	COOKED	1	5	BAT	10	934	927

Table B-9. Continued

Date	CON	Rep	Day	Trt	Fat	T OFF1	T OFF2
7/15/2005	COOKED	1	5	ROS	10	955	957
7/15/2005	COOKED	1	5	LSM	10	1021	1022
7/15/2005	COOKED	1	5	MSM	10	1049	1049
7/15/2005	COOKED	1	5	HSM	10	1114	1115
7/15/2005	COOKED	1	5	CON	27	1142	1138
7/15/2005	COOKED	1	5	BAT	27	1209	1206
7/15/2005	COOKED	1	5	ROS	27	1236	1229
7/15/2005	COOKED	1	5	LSM	27	1301	1302
7/15/2005	COOKED	1	5	MSM	27	1332	1329
7/15/2005	COOKED	1	5	HSM	27	1356	1357
7/17/2005	COOKED	2	0	CON	10	834	834
7/17/2005	COOKED	2	0	BAT	10	854	857
7/17/2005	COOKED	2	0	ROS	10	917	917
7/17/2005	COOKED	2	0	LSM	10	934	934
7/17/2005	COOKED	2	0	MSM	10	958	958
7/17/2005	COOKED	2	0	HSM	10	1018	1018
7/17/2005	COOKED	2	0	CON	27	1035	1036
7/17/2005	COOKED	2	0	BAT	27	1057	1057
7/17/2005	COOKED	2	0	ROS	27	1127	1125
7/17/2005	COOKED	2	0	LSM	27	1149	1149
7/17/2005	COOKED	2	0	MSM	27	1220	1220
7/17/2005	COOKED	2	0	HSM	27	1235	1235
7/18/2005	COOKED	2	1	CON	10	833	833
7/18/2005	COOKED	2	1	BAT	10	858	853
7/18/2005	COOKED	2	1	ROS	10	916	918
7/18/2005	COOKED	2	1	LSM	10	935	939
7/18/2005	COOKED	2	1	MSM	10	954	958
7/18/2005	COOKED	2	1	HSM	10	1015	1014
7/18/2005	COOKED	2	1	CON	27	1038	1038
7/18/2005	COOKED	2	1	BAT	27	1058	1058
7/18/2005	COOKED	2	1	ROS	27	1126	1127
7/18/2005	COOKED	2	1	LSM	27	1151	1151
7/18/2005	COOKED	2	1	MSM	27	1220	1220
7/18/2005	COOKED	2	1	HSM	27	1235	1235
7/20/2005	COOKED	2	3	CON	10	832	832
7/20/2005	COOKED	2	3	BAT	10	855	855
7/20/2005	COOKED	2	3	ROS	10	919	919
7/20/2005	COOKED	2	3	LSM	10	937	940

Table B-9. Continued

Date	CON	Rep	Day	Trt	Fat	T OFF1	T OFF2
7/20/2005	COOKED	2	3	MSM	10	959	959
7/20/2005	COOKED	2	3	HSM	10	1017	1017
7/20/2005	COOKED	2	3	CON	27	1043	1043
7/20/2005	COOKED	2	3	BAT	27	1100	1100
7/20/2005	COOKED	2	3	ROS	27	1128	1128
7/20/2005	COOKED	2	3	LSM	27	1154	1154
7/20/2005	COOKED	2	3	MSM	27	1214	1214
7/20/2005	COOKED	2	3	HSM	27	1242	1242
7/22/2005	COOKED	2	5	CON	10	835	835
7/22/2005	COOKED	2	5	BAT	10	855	856
7/22/2005	COOKED	2	5	ROS	10	920	920
7/22/2005	COOKED	2	5	LSM	10	936	936
7/22/2005	COOKED	2	5	MSM	10	959	959
7/22/2005	COOKED	2	5	HSM	10	1023	1023
7/22/2005	COOKED	2	5	CON	27	1043	1043
7/22/2005	COOKED	2	5	BAT	27	1100	1100
7/22/2005	COOKED	2	5	ROS	27	1128	1128
7/22/2005	COOKED	2	5	LSM	27	1154	1154
7/22/2005	COOKED	2	5	MSM	27	1213	1213
7/22/2005	COOKED	2	5	HSM	27	1243	1242
9/18/2005	COOKED	3	0	CON	10	813	815
9/18/2005	COOKED	3	0	BAT	10	842	842
9/18/2005	COOKED	3	0	ROS	10	906	905
9/18/2005	COOKED	3	0	LSM	10	930	930
9/18/2005	COOKED	3	0	MSM	10	952	952
9/18/2005	COOKED	3	0	HSM	10	750	753
9/18/2005	COOKED	3	0	CON	27	1149	1148
9/18/2005	COOKED	3	0	BAT	27	1017	1017
9/18/2005	COOKED	3	0	ROS	27	1106	1107
9/18/2005	COOKED	3	0	LSM	27	1041	1041
9/18/2005	COOKED	3	0	MSM	27	1129	1129
9/18/2005	COOKED	3	0	HSM	27	1209	1208
9/19/2005	COOKED	3	1	CON	10	812	816
9/19/2005	COOKED	3	1	BAT	10	839	839
9/19/2005	COOKED	3	1	ROS	10	906	905
9/19/2005	COOKED	3	1	LSM	10	929	929
9/19/2005	COOKED	3	1	MSM	10	951	952
9/19/2005	COOKED	3	1	HSM	10	749	751

Table B-9. Continued

Date	CON	Rep	Day	Trt	Fat	T OFF1	T OFF2
9/19/2005	COOKED	3	1	CON	27	1148	1148
9/19/2005	COOKED	3	1	BAT	27	1017	1017
9/19/2005	COOKED	3	1	ROS	27	1106	1106
9/19/2005	COOKED	3	1	LSM	27	1041	1043
9/19/2005	COOKED	3	1	MSM	27	1128	1128
9/19/2005	COOKED	3	1	HSM	27	1208	1209
9/21/2005	COOKED	3	3	CON	10	821	821
9/21/2005	COOKED	3	3	BAT	10	843	844
9/21/2005	COOKED	3	3	ROS	10	909	908
9/21/2005	COOKED	3	3	LSM	10	934	934
9/21/2005	COOKED	3	3	MSM	10	956	955
9/21/2005	COOKED	3	3	HSM	10	756	756
9/21/2005	COOKED	3	3	CON	27	1153	1153
9/21/2005	COOKED	3	3	BAT	27	1019	1019
9/21/2005	COOKED	3	3	ROS	27	1111	1111
9/21/2005	COOKED	3	3	LSM	27	1047	1047
9/21/2005	COOKED	3	3	MSM	27	1131	1131
9/21/2005	COOKED	3	3	HSM	27	1219	1219
9/29/2005	COOKED	3	5	CON	10	821	821
9/29/2005	COOKED	3	5	BAT	10	844	845
9/29/2005	COOKED	3	5	ROS	10	907	908
9/29/2005	COOKED	3	5	LSM	10	933	933
9/29/2005	COOKED	3	5	MSM	10	955	955
9/29/2005	COOKED	3	5	HSM	10	755	756
9/29/2005	COOKED	3	5	CON	27	1153	1154
9/29/2005	COOKED	3	5	BAT	27	1019	1020
9/29/2005	COOKED	3	5	ROS	27	1112	1112
9/29/2005	COOKED	3	5	LSM	27	1046	1047
9/29/2005	COOKED	3	5	MSM	27	1131	1132
9/29/2005	COOKED	3	5	HSM	27	1220	1219

Table B-10. Raw pH data table of the cooked gound beef patties

Date	CON	Rep	Day	Trt	Fat	pH1	pH2	pH3
7/10/2005	COOKED	1	0	CON	10	6.29	6.26	6.26
7/10/2005	COOKED	1	0	BAT	10	6.29	6.31	6.3
7/10/2005	COOKED	1	0	ROS	10	6.19	6.23	6.25
7/10/2005	COOKED	1	0	LSM	10	6.13	6.17	6.19
7/10/2005	COOKED	1	0	MSM	10	6.15	6.14	6.14
7/10/2005	COOKED	1	0	HSM	10	6.12	6.15	6.17
7/10/2005	COOKED	1	0	CON	27	6.03	6.05	6.12
7/10/2005	COOKED	1	0	BAT	27	6.13	6.18	6.21
7/10/2005	COOKED	1	0	ROS	27	6.24	6.18	6.19
7/10/2005	COOKED	1	0	LSM	27	6.11	6.19	6.16
7/10/2005	COOKED	1	0	MSM	27	6.11	6.12	6.14
7/10/2005	COOKED	1	0	HSM	27	6.04	6	6
7/11/2005	COOKED	1	1	CON	10	6.07	6.03	6.03
7/11/2005	COOKED	1	1	BAT	10	6.11	6.17	6.16
7/11/2005	COOKED	1	1	ROS	10	6.1	6.13	6.09
7/11/2005	COOKED	1	1	LSM	10	6.08	6.1	6.13
7/11/2005	COOKED	1	1	MSM	10	6.09	6.09	6.08
7/11/2005	COOKED	1	1	HSM	10	6.09	6.13	6.12
7/11/2005	COOKED	1	1	CON	27	6.17	6.15	6.18
7/11/2005	COOKED	1	1	BAT	27	6.17	6.2	6.17
7/11/2005	COOKED	1	1	ROS	27	6.11	6.13	6.14
7/11/2005	COOKED	1	1	LSM	27	6.26	6.15	6.16
7/11/2005	COOKED	1	1	MSM	27	5.97	6.06	6.1
7/11/2005	COOKED	1	1	HSM	27	6.13	6.17	6.19
7/13/2005	COOKED	1	3	CON	10	6.37	6.37	6.38
7/13/2005	COOKED	1	3	BAT	10	6.4	6.4	6.37
7/13/2005	COOKED	1	3	ROS	10	6.4	6.36	6.38
7/13/2005	COOKED	1	3	LSM	10	6.42	6.46	6.4
7/13/2005	COOKED	1	3	MSM	10	6.34	6.36	6.36
7/13/2005	COOKED	1	3	HSM	10	6.44	6.4	6.38
7/13/2005	COOKED	1	3	CON	27	6.39	6.41	6.44
7/13/2005	COOKED	1	3	BAT	27	6.49	6.5	6.5
7/13/2005	COOKED	1	3	ROS	27	6.56	6.59	6.59
7/13/2005	COOKED	1	3	LSM	27	6.55	6.55	6.57
7/13/2005	COOKED	1	3	MSM	27	6.47	6.51	6.5
7/13/2005	COOKED	1	3	HSM	27	6.47	6.49	6.46
7/15/2005	COOKED	1	5	CON	10	6.47	6.48	6.52
7/15/2005	COOKED	1	5	BAT	10	6.41	6.31	6.4

Table B-10. Continued

Date	CON	Rep	Day	Trt	Fat	pH1	pH2	pH3
7/15/2005	COOKED	1	5	ROS	10	6.53	6.53	6.62
7/15/2005	COOKED	1	5	LSM	10	6.45	6.58	6.58
7/15/2005	COOKED	1	5	MSM	10	6.52	6.57	6.57
7/15/2005	COOKED	1	5	HSM	10	6.5	6.58	6.59
7/15/2005	COOKED	1	5	CON	27	6.53	6.61	6.58
7/15/2005	COOKED	1	5	BAT	27	6.46	6.54	6.48
7/15/2005	COOKED	1	5	ROS	27	6.47	6.53	6.5
7/15/2005	COOKED	1	5	LSM	27	6.53	6.57	6.53
7/15/2005	COOKED	1	5	MSM	27	6.59	6.58	6.53
7/15/2005	COOKED	1	5	HSM	27	6.48	6.55	6.53
7/17/2005	COOKED	2	0	CON	10	6.53	6.48	6.55
7/17/2005	COOKED	2	0	BAT	10	6.27	6.29	6.34
7/17/2005	COOKED	2	0	ROS	10	6.3	6.34	6.33
7/17/2005	COOKED	2	0	LSM	10	6.25	6.25	6.32
7/17/2005	COOKED	2	0	MSM	10	6.37	6.35	6.37
7/17/2005	COOKED	2	0	HSM	10	6.34	6.34	6.35
7/17/2005	COOKED	2	0	CON	27	6.18	6.23	6.19
7/17/2005	COOKED	2	0	BAT	27	6.16	6.12	6.07
7/17/2005	COOKED	2	0	ROS	27	6.12	6.12	6.12
7/17/2005	COOKED	2	0	LSM	27	6.11	6.11	6.1
7/17/2005	COOKED	2	0	MSM	27	5.78	6.06	5.9
7/17/2005	COOKED	2	0	HSM	27	6.19	5.95	5.87
7/18/2005	COOKED	2	1	CON	10	5.97	5.99	6.07
7/18/2005	COOKED	2	1	BAT	10	6.33	6.25	6.21
7/18/2005	COOKED	2	1	ROS	10	6.29	6.34	6.34
7/18/2005	COOKED	2	1	LSM	10	6.25	6.28	6.22
7/18/2005	COOKED	2	1	MSM	10	6.24	6.32	6.31
7/18/2005	COOKED	2	1	HSM	10	6.29	6.33	6.33
7/18/2005	COOKED	2	1	CON	27	6.29	6.33	6.35
7/18/2005	COOKED	2	1	BAT	27	6.21	6.27	6.3
7/18/2005	COOKED	2	1	ROS	27	6.26	6.3	6.37
7/18/2005	COOKED	2	1	LSM	27	6.36	6.36	6.41
7/18/2005	COOKED	2	1	MSM	27	6.43	6.45	6.45
7/18/2005	COOKED	2	1	HSM	27	6.38	6.34	6.32
7/20/2005	COOKED	2	3	CON	10	5.94	5.95	5.99
7/20/2005	COOKED	2	3	BAT	10	6.27	6.26	6.27
7/20/2005	COOKED	2	3	ROS	10	6.26	6.21	6.18
7/20/2005	COOKED	2	3	LSM	10	6.06	6.05	6.06

Table B-10. Continued

Date	CON	Rep	Day	Trt	Fat	pH1	pH2	pH3
7/20/2005	COOKED	2	3	MSM	10	6.16	6.17	6.22
7/20/2005	COOKED	2	3	HSM	10	6.15	6.15	6.17
7/20/2005	COOKED	2	3	CON	27	6.17	6.16	6.18
7/20/2005	COOKED	2	3	BAT	27	6.14	6.14	6.16
7/20/2005	COOKED	2	3	ROS	27	6.12	6.2	6.23
7/20/2005	COOKED	2	3	LSM	27	6.21	6.21	6.25
7/20/2005	COOKED	2	3	MSM	27	6.27	6.32	6.33
7/20/2005	COOKED	2	3	HSM	27	6.21	6.23	6.25
7/22/2005	COOKED	2	5	CON	10	6.23	6.23	6.19
7/22/2005	COOKED	2	5	BAT	10	5.98	6	6.03
7/22/2005	COOKED	2	5	ROS	10	6.1	6.15	6.11
7/22/2005	COOKED	2	5	LSM	10	6.16	6.22	6.22
7/22/2005	COOKED	2	5	MSM	10	6.28	6.34	6.35
7/22/2005	COOKED	2	5	HSM	10	6.19	6.24	6.25
7/22/2005	COOKED	2	5	CON	27	6.33	6.29	6.34
7/22/2005	COOKED	2	5	BAT	27	6.27	6.27	6.27
7/22/2005	COOKED	2	5	ROS	27	6.3	6.26	6.37
7/22/2005	COOKED	2	5	LSM	27	6.21	6.25	6.25
7/22/2005	COOKED	2	5	MSM	27	6.35	6.39	6.38
7/22/2005	COOKED	2	5	HSM	27	6.39	9.37	6.34
9/18/2005	COOKED	3	0	CON	10	6.58	6.6	.
9/18/2005	COOKED	3	0	BAT	10	6.49	6.46	.
9/18/2005	COOKED	3	0	ROS	10	6.31	6.33	.
9/18/2005	COOKED	3	0	LSM	10	6.29	6.3	.
9/18/2005	COOKED	3	0	MSM	10	6.28	6.25	.
9/18/2005	COOKED	3	0	HSM	10	6.23	6.25	.
9/18/2005	COOKED	3	0	CON	27	6.01	5.95	.
9/18/2005	COOKED	3	0	BAT	27	6.37	6.29	.
9/18/2005	COOKED	3	0	ROS	27	6.22	6.1	.
9/18/2005	COOKED	3	0	LSM	27	6.1	6.06	.
9/18/2005	COOKED	3	0	MSM	27	6.04	6.01	.
9/18/2005	COOKED	3	0	HSM	27	5.86	5.72	.
9/19/2005	COOKED	3	1	CON	10	6.07	6.02	.
9/19/2005	COOKED	3	1	BAT	10	6.06	6.08	.
9/19/2005	COOKED	3	1	ROS	10	6.09	6.06	.
9/19/2005	COOKED	3	1	LSM	10	6.19	6.16	.
9/19/2005	COOKED	3	1	MSM	10	6.11	6.08	.
9/19/2005	COOKED	3	1	HSM	10	6.19	6.15	.

Table B-10. Continued

Date	CON	Rep	Day	Trt	Fat	pH1	pH2	pH3
9/19/2005	COOKED	3	1	CON	27	6.08	6.08	.
9/19/2005	COOKED	3	1	BAT	27	6.13	6.14	.
9/19/2005	COOKED	3	1	ROS	27	6.09	6.12	.
9/19/2005	COOKED	3	1	LSM	27	6.08	6.08	.
9/19/2005	COOKED	3	1	MSM	27	6.06	6.04	.
9/19/2005	COOKED	3	1	HSM	27	5.95	5.94	.
9/21/2005	COOKED	3	3	CON	10	6.03	6.02	.
9/21/2005	COOKED	3	3	BAT	10	6.12	6.12	.
9/21/2005	COOKED	3	3	ROS	10	6.11	6.12	.
9/21/2005	COOKED	3	3	LSM	10	6.15	6.15	.
9/21/2005	COOKED	3	3	MSM	10	6.14	6.13	.
9/21/2005	COOKED	3	3	HSM	10	6.12	6.08	.
9/21/2005	COOKED	3	3	CON	27	6.1	6.14	.
9/21/2005	COOKED	3	3	BAT	27	6.25	6.27	.
9/21/2005	COOKED	3	3	ROS	27	6.14	6.14	.
9/21/2005	COOKED	3	3	LSM	27	6.17	6.17	.
9/21/2005	COOKED	3	3	MSM	27	6.14	6.17	.
9/21/2005	COOKED	3	3	HSM	27	6.13	6.14	.
9/29/2005	COOKED	3	5	CON	10	6.16	6.13	.
9/29/2005	COOKED	3	5	BAT	10	6.18	6.19	.
9/29/2005	COOKED	3	5	ROS	10	6.24	6.21	.
9/29/2005	COOKED	3	5	LSM	10	6.25	6.22	.
9/29/2005	COOKED	3	5	MSM	10	6.19	6.18	.
9/29/2005	COOKED	3	5	HSM	10	6.21	6.19	.
9/29/2005	COOKED	3	5	CON	27	6.19	6.2	.
9/29/2005	COOKED	3	5	BAT	27	6.32	6.24	.
9/29/2005	COOKED	3	5	ROS	27	6.21	6.19	.
9/29/2005	COOKED	3	5	LSM	27	6.24	6.23	.
9/29/2005	COOKED	3	5	MSM	27	6.19	6.2	.
9/29/2005	COOKED	3	5	HSM	27	6.22	6.18	.

Table B-11. Raw L* (lightness) data table of the cooked gound beef patties

Date	CON	Rep	Day	Trt	Fat	L*1	L*2	L*3
7/10/2005	COOKED	1	0	CON	10	46.43	46.87	48.48
7/10/2005	COOKED	1	0	BAT	10	48.98	47.1	47.22
7/10/2005	COOKED	1	0	ROS	10	46.02	45.52	43.2
7/10/2005	COOKED	1	0	LSM	10	44.83	47.46	45.09
7/10/2005	COOKED	1	0	MSM	10	44.89	41.36	43.55
7/10/2005	COOKED	1	0	HSM	10	40.7	46.3	45.92
7/10/2005	COOKED	1	0	CON	27	46.13	45.11	48.16
7/10/2005	COOKED	1	0	BAT	27	44.39	43.65	45.43
7/10/2005	COOKED	1	0	ROS	27	41.78	40.24	43.04
7/10/2005	COOKED	1	0	LSM	27	45.01	42.68	42.61
7/10/2005	COOKED	1	0	MSM	27	43.59	40.49	44.13
7/10/2005	COOKED	1	0	HSM	27	38.79	36.46	37.53
7/11/2005	COOKED	1	1	CON	10	52.38	49.53	51.67
7/11/2005	COOKED	1	1	BAT	10	46.43	44.53	50.66
7/11/2005	COOKED	1	1	ROS	10	47.81	49.41	49.51
7/11/2005	COOKED	1	1	LSM	10	46.03	48.42	48.76
7/11/2005	COOKED	1	1	MSM	10	47.26	43.52	47.73
7/11/2005	COOKED	1	1	HSM	10	49.15	44.76	47.11
7/11/2005	COOKED	1	1	CON	27	45.5	46.8	44.72
7/11/2005	COOKED	1	1	BAT	27	46.65	40.65	46.75
7/11/2005	COOKED	1	1	ROS	27	46.71	44.74	49.14
7/11/2005	COOKED	1	1	LSM	27	48.18	44.46	44.24
7/11/2005	COOKED	1	1	MSM	27	42.41	46	41.13
7/11/2005	COOKED	1	1	HSM	27	40.81	38.73	37.9
7/13/2005	COOKED	1	3	CON	10	47.09	45.74	43.81
7/13/2005	COOKED	1	3	BAT	10	48.55	47.17	46.88
7/13/2005	COOKED	1	3	ROS	10	49.67	49.39	49.8
7/13/2005	COOKED	1	3	LSM	10	44.13	45.94	48.77
7/13/2005	COOKED	1	3	MSM	10	47.42	46.46	48.03
7/13/2005	COOKED	1	3	HSM	10	47.23	49.45	47.87
7/13/2005	COOKED	1	3	CON	27	52.79	47.13	48.24
7/13/2005	COOKED	1	3	BAT	27	42.37	42.93	46.52
7/13/2005	COOKED	1	3	ROS	27	42.84	45.8	49.56
7/13/2005	COOKED	1	3	LSM	27	47.47	44.28	43.65
7/13/2005	COOKED	1	3	MSM	27	44.91	45.16	48.46
7/13/2005	COOKED	1	3	HSM	27	42.47	45.38	40.2
7/15/2005	COOKED	1	5	CON	10	47.5	46.21	54.93
7/15/2005	COOKED	1	5	BAT	10	47.32	51.03	49.36

Table B-11. Continued

Date	CON	Rep	Day	Trt	Fat	L*1	L*2	L*3
7/15/2005	COOKED	1	5	ROS	10	43.96	49.64	46.81
7/15/2005	COOKED	1	5	LSM	10	50.35	44.12	47.72
7/15/2005	COOKED	1	5	MSM	10	44.58	45.63	47.38
7/15/2005	COOKED	1	5	HSM	10	48.42	45.66	47.45
7/15/2005	COOKED	1	5	CON	27	46.76	44.74	42.32
7/15/2005	COOKED	1	5	BAT	27	46.6	43.67	48.34
7/15/2005	COOKED	1	5	ROS	27	43.6	44.63	46.75
7/15/2005	COOKED	1	5	LSM	27	43.95	45.52	46.13
7/15/2005	COOKED	1	5	MSM	27	44.63	41.57	47.02
7/15/2005	COOKED	1	5	HSM	27	45.54	48.14	46.1
7/17/2005	COOKED	2	0	CON	10	46.24	45.57	43.67
7/17/2005	COOKED	2	0	BAT	10	45.78	45.06	45.21
7/17/2005	COOKED	2	0	ROS	10	48.78	47.8	46.93
7/17/2005	COOKED	2	0	LSM	10	43.26	47.67	48.94
7/17/2005	COOKED	2	0	MSM	10	47.2	50.71	46.29
7/17/2005	COOKED	2	0	HSM	10	42.22	45.83	45.22
7/17/2005	COOKED	2	0	CON	27	45.51	41.78	43.28
7/17/2005	COOKED	2	0	BAT	27	45.59	44.7	45.53
7/17/2005	COOKED	2	0	ROS	27	45.73	43.08	46.64
7/17/2005	COOKED	2	0	LSM	27	42.39	39.73	41.54
7/17/2005	COOKED	2	0	MSM	27	42.65	42.35	38.94
7/17/2005	COOKED	2	0	HSM	27	39.06	38.1	49.08
7/18/2005	COOKED	2	1	CON	10	46.96	48.62	43.63
7/18/2005	COOKED	2	1	BAT	10	50.61	50.15	46.97
7/18/2005	COOKED	2	1	ROS	10	45.4	47.41	48.17
7/18/2005	COOKED	2	1	LSM	10	42.75	47.56	49.83
7/18/2005	COOKED	2	1	MSM	10	45.58	44.55	45.98
7/18/2005	COOKED	2	1	HSM	10	43.59	46.32	44.6
7/18/2005	COOKED	2	1	CON	27	46.69	49.46	50.76
7/18/2005	COOKED	2	1	BAT	27	50.76	45.31	45.46
7/18/2005	COOKED	2	1	ROS	27	47.81	43.33	45.54
7/18/2005	COOKED	2	1	LSM	27	40.56	44.25	41.86
7/18/2005	COOKED	2	1	MSM	27	46.61	43.82	44.47
7/18/2005	COOKED	2	1	HSM	27	45.07	42.96	43.15
7/20/2005	COOKED	2	3	CON	10	45.89	46.55	46.47
7/20/2005	COOKED	2	3	BAT	10	45.14	46.89	46.31
7/20/2005	COOKED	2	3	ROS	10	50.7	45.42	45.37
7/20/2005	COOKED	2	3	LSM	10	47.23	48.97	48.18

Table B-11. Continued

Date	CON	Rep	Day	Trt	Fat	L*1	L*2	L*3
7/20/2005	COOKED	2	3	MSM	10	46.92	44.32	43.13
7/20/2005	COOKED	2	3	HSM	10	45.9	42.81	46.77
7/20/2005	COOKED	2	3	CON	27	44.66	47.59	49.48
7/20/2005	COOKED	2	3	BAT	27	45.76	48.48	46.95
7/20/2005	COOKED	2	3	ROS	27	48.24	45.43	48.5
7/20/2005	COOKED	2	3	LSM	27	48.91	50.52	51.02
7/20/2005	COOKED	2	3	MSM	27	47.43	46.08	44.44
7/20/2005	COOKED	2	3	HSM	27	43.51	46.54	43.77
7/22/2005	COOKED	2	5	CON	10	49.16	44.12	49.87
7/22/2005	COOKED	2	5	BAT	10	47.04	48.54	50.13
7/22/2005	COOKED	2	5	ROS	10	46.16	46.14	47.03
7/22/2005	COOKED	2	5	LSM	10	47.39	45.7	49.66
7/22/2005	COOKED	2	5	MSM	10	48.09	45.96	45.92
7/22/2005	COOKED	2	5	HSM	10	43.45	45.19	46.7
7/22/2005	COOKED	2	5	CON	27	46.28	48.11	49.03
7/22/2005	COOKED	2	5	BAT	27	51.56	49.11	43.98
7/22/2005	COOKED	2	5	ROS	27	50.52	49.27	52.37
7/22/2005	COOKED	2	5	LSM	27	49.87	45.17	45.15
7/22/2005	COOKED	2	5	MSM	27	46.08	50.8	49.56
7/22/2005	COOKED	2	5	HSM	27	43.05	48.51	43.07
9/18/2005	COOKED	3	0	CON	10	46.46	42.27	48.62
9/18/2005	COOKED	3	0	BAT	10	52.37	50.05	51.29
9/18/2005	COOKED	3	0	ROS	10	53.09	48.12	53.84
9/18/2005	COOKED	3	0	LSM	10	50.65	48.09	55.05
9/18/2005	COOKED	3	0	MSM	10	51.27	50.66	49.68
9/18/2005	COOKED	3	0	HSM	10	48.19	46.34	46.39
9/18/2005	COOKED	3	0	CON	27	49.25	48.09	47.84
9/18/2005	COOKED	3	0	BAT	27	50.86	49.95	44.95
9/18/2005	COOKED	3	0	ROS	27	50.34	48.34	45.31
9/18/2005	COOKED	3	0	LSM	27	56.41	47.65	44.42
9/18/2005	COOKED	3	0	MSM	27	48.25	45.14	49.2
9/18/2005	COOKED	3	0	HSM	27	41.52	40.11	44.67
9/19/2005	COOKED	3	1	CON	10	53.79	50.85	53.03
9/19/2005	COOKED	3	1	BAT	10	54.31	48.48	52.11
9/19/2005	COOKED	3	1	ROS	10	54.47	55.05	47.82
9/19/2005	COOKED	3	1	LSM	10	47.98	49.87	51.57
9/19/2005	COOKED	3	1	MSM	10	47.29	53.2	50.98
9/19/2005	COOKED	3	1	HSM	10	50.42	46.31	45.52

Table B-11. Continued

Date	CON	Rep	Day	Trt	Fat	L*1	L*2	L*3
9/19/2005	COOKED	3	1	CON	27	57.41	47.05	51.38
9/19/2005	COOKED	3	1	BAT	27	54.07	53.44	52.89
9/19/2005	COOKED	3	1	ROS	27	46	44.88	49.16
9/19/2005	COOKED	3	1	LSM	27	48.1	49.97	49.41
9/19/2005	COOKED	3	1	MSM	27	52.03	49.83	48.47
9/19/2005	COOKED	3	1	HSM	27	52.6	46.04	47.42
9/21/2005	COOKED	3	3	CON	10	54.04	45.62	48.96
9/21/2005	COOKED	3	3	BAT	10	49.64	49.45	48.71
9/21/2005	COOKED	3	3	ROS	10	54	48.19	51.26
9/21/2005	COOKED	3	3	LSM	10	52.69	51.26	54.2
9/21/2005	COOKED	3	3	MSM	10	49.47	50.79	48.24
9/21/2005	COOKED	3	3	HSM	10	53.18	49.29	50.43
9/21/2005	COOKED	3	3	CON	27	44.92	51.51	50.98
9/21/2005	COOKED	3	3	BAT	27	51.55	45.81	53.05
9/21/2005	COOKED	3	3	ROS	27	49.45	52.23	51.52
9/21/2005	COOKED	3	3	LSM	27	48.58	60.66	51.64
9/21/2005	COOKED	3	3	MSM	27	49.53	51.96	50.82
9/21/2005	COOKED	3	3	HSM	27	49.16	52.62	48.8
9/29/2005	COOKED	3	5	CON	10	44.74	47.33	46.73
9/29/2005	COOKED	3	5	BAT	10	49.19	50.11	50.25
9/29/2005	COOKED	3	5	ROS	10	45.3	47.86	46.79
9/29/2005	COOKED	3	5	LSM	10	47.07	42.68	48.06
9/29/2005	COOKED	3	5	MSM	10	45.57	47.75	43.89
9/29/2005	COOKED	3	5	HSM	10	47.47	48.27	47.08
9/29/2005	COOKED	3	5	CON	27	45.39	46.22	46.61
9/29/2005	COOKED	3	5	BAT	27	48.12	47.84	46.46
9/29/2005	COOKED	3	5	ROS	27	46.95	49.25	46.95
9/29/2005	COOKED	3	5	LSM	27	50.94	48.32	50.52
9/29/2005	COOKED	3	5	MSM	27	47.07	46.34	48.86
9/29/2005	COOKED	3	5	HSM	27	47.45	46.09	49.65

Table B-12. Raw a* (redness) data table of the cooked gound beef patties

Date	CON	Rep	Day	Trt	Fat	a*1	a*2	a*3
7/10/2005	COOKED	1	0	CON	10	9.42	10.79	11.32
7/10/2005	COOKED	1	0	BAT	10	8.19	7.23	9.73
7/10/2005	COOKED	1	0	ROS	10	8.54	8.8	8.38
7/10/2005	COOKED	1	0	LSM	10	9.95	8.19	8.6
7/10/2005	COOKED	1	0	MSM	10	8.95	12.76	11.36
7/10/2005	COOKED	1	0	HSM	10	7.78	7.66	6.65
7/10/2005	COOKED	1	0	CON	27	9.19	9.34	6.86
7/10/2005	COOKED	1	0	BAT	27	5.6	6.15	7.28
7/10/2005	COOKED	1	0	ROS	27	5.99	6.06	6.08
7/10/2005	COOKED	1	0	LSM	27	7.41	6.19	6.55
7/10/2005	COOKED	1	0	MSM	27	7.31	7.66	5.37
7/10/2005	COOKED	1	0	HSM	27	5.84	6.63	6.29
7/11/2005	COOKED	1	1	CON	10	7.68	9.09	7.45
7/11/2005	COOKED	1	1	BAT	10	7.8	7.97	8.77
7/11/2005	COOKED	1	1	ROS	10	7.8	8.99	8.5
7/11/2005	COOKED	1	1	LSM	10	8.3	7.14	7.32
7/11/2005	COOKED	1	1	MSM	10	7.64	9.18	8.56
7/11/2005	COOKED	1	1	HSM	10	8.26	8.41	9.06
7/11/2005	COOKED	1	1	CON	27	7.64	7.77	7.58
7/11/2005	COOKED	1	1	BAT	27	7.89	8.03	7.05
7/11/2005	COOKED	1	1	ROS	27	8.41	7.54	7.04
7/11/2005	COOKED	1	1	LSM	27	7.05	6.94	7.93
7/11/2005	COOKED	1	1	MSM	27	10.61	8.1	8.15
7/11/2005	COOKED	1	1	HSM	27	5.88	7.41	7.24
7/13/2005	COOKED	1	3	CON	10	7.82	9.38	10.14
7/13/2005	COOKED	1	3	BAT	10	10.6	11.18	10.39
7/13/2005	COOKED	1	3	ROS	10	8.36	9.36	8.35
7/13/2005	COOKED	1	3	LSM	10	9.68	9.4	7.35
7/13/2005	COOKED	1	3	MSM	10	7.7	7.71	8.16
7/13/2005	COOKED	1	3	HSM	10	7.76	8.18	7.18
7/13/2005	COOKED	1	3	CON	27	5.47	8.08	7.3
7/13/2005	COOKED	1	3	BAT	27	6.05	6.39	6.1
7/13/2005	COOKED	1	3	ROS	27	7.79	8.77	6.89
7/13/2005	COOKED	1	3	LSM	27	6.07	5.67	7.44
7/13/2005	COOKED	1	3	MSM	27	7.87	7.78	7.35
7/13/2005	COOKED	1	3	HSM	27	6.73	5.18	6.49
7/15/2005	COOKED	1	5	CON	10	8.77	9.01	6.65
7/15/2005	COOKED	1	5	BAT	10	7.25	7.31	9.42

Table B-12. Continued

Date	CON	Rep	Day	Trt	Fat	a*1	a*2	a*3
7/15/2005	COOKED	1	5	ROS	10	9.6	8.03	8.3
7/15/2005	COOKED	1	5	LSM	10	7.28	9.05	8.21
7/15/2005	COOKED	1	5	MSM	10	8.91	9.23	9
7/15/2005	COOKED	1	5	HSM	10	8.07	8.83	8.7
7/15/2005	COOKED	1	5	CON	27	6.95	6.82	6.6
7/15/2005	COOKED	1	5	BAT	27	6.11	7.68	8.53
7/15/2005	COOKED	1	5	ROS	27	6.88	7.5	6.62
7/15/2005	COOKED	1	5	LSM	27	5.23	6.44	5.37
7/15/2005	COOKED	1	5	MSM	27	5.96	7.83	5.8
7/15/2005	COOKED	1	5	HSM	27	7.53	6.64	7.45
7/17/2005	COOKED	2	0	CON	10	8.51	9.81	10.29
7/17/2005	COOKED	2	0	BAT	10	12.09	12.19	12.75
7/17/2005	COOKED	2	0	ROS	10	9.18	10.09	9.59
7/17/2005	COOKED	2	0	LSM	10	8.22	8.96	8.09
7/17/2005	COOKED	2	0	MSM	10	8.55	7.8	9.41
7/17/2005	COOKED	2	0	HSM	10	8.62	7.75	8.5
7/17/2005	COOKED	2	0	CON	27	7.52	6.63	8.18
7/17/2005	COOKED	2	0	BAT	27	7.8	8.44	7.01
7/17/2005	COOKED	2	0	ROS	27	7.57	8.32	6.65
7/17/2005	COOKED	2	0	LSM	27	7.01	8.53	8.61
7/17/2005	COOKED	2	0	MSM	27	5.73	6.3	7.84
7/17/2005	COOKED	2	0	HSM	27	7.16	8.36	6.7
7/18/2005	COOKED	2	1	CON	10	7.66	8.12	9.33
7/18/2005	COOKED	2	1	BAT	10	11.04	9.88	11.61
7/18/2005	COOKED	2	1	ROS	10	9.32	7.16	9.23
7/18/2005	COOKED	2	1	LSM	10	9.94	9.42	8.66
7/18/2005	COOKED	2	1	MSM	10	9.25	9.28	7.86
7/18/2005	COOKED	2	1	HSM	10	9.57	9.33	9.66
7/18/2005	COOKED	2	1	CON	27	9.08	7.47	8.56
7/18/2005	COOKED	2	1	BAT	27	6.97	6.35	8.82
7/18/2005	COOKED	2	1	ROS	27	8.87	8.67	9.58
7/18/2005	COOKED	2	1	LSM	27	7.08	6	5.95
7/18/2005	COOKED	2	1	MSM	27	5.51	6.96	6.56
7/18/2005	COOKED	2	1	HSM	27	4.93	5.83	5.88
7/20/2005	COOKED	2	3	CON	10	10.89	10.49	10.75
7/20/2005	COOKED	2	3	BAT	10	8.39	9.07	9.36
7/20/2005	COOKED	2	3	ROS	10	10.2	11.01	10.72
7/20/2005	COOKED	2	3	LSM	10	10.19	7.97	8.48

Table B-12. Continued

Date	CON	Rep	Day	Trt	Fat	a*1	a*2	a*3
7/20/2005	COOKED	2	3	MSM	10	9.48	8.54	10.12
7/20/2005	COOKED	2	3	HSM	10	9.05	10.14	9.11
7/20/2005	COOKED	2	3	CON	27	5.6	8.51	8.44
7/20/2005	COOKED	2	3	BAT	27	7.17	6.33	7.52
7/20/2005	COOKED	2	3	ROS	27	7.8	8.47	8.68
7/20/2005	COOKED	2	3	LSM	27	5.64	5.96	5.79
7/20/2005	COOKED	2	3	MSM	27	5.72	6.2	5.38
7/20/2005	COOKED	2	3	HSM	27	8.53	6.66	7.68
7/22/2005	COOKED	2	5	CON	10	7.2	8.15	9.87
7/22/2005	COOKED	2	5	BAT	10	10.1	10.11	11.34
7/22/2005	COOKED	2	5	ROS	10	11.4	10.6	11.23
7/22/2005	COOKED	2	5	LSM	10	8.44	8.99	7.14
7/22/2005	COOKED	2	5	MSM	10	7.15	8.62	7.8
7/22/2005	COOKED	2	5	HSM	10	9.22	9.32	9.67
7/22/2005	COOKED	2	5	CON	27	7.09	9.27	9.56
7/22/2005	COOKED	2	5	BAT	27	6.48	6.86	7.98
7/22/2005	COOKED	2	5	ROS	27	7.13	6.42	5.69
7/22/2005	COOKED	2	5	LSM	27	6.08	7.73	7.5
7/22/2005	COOKED	2	5	MSM	27	7.56	7.33	6.8
7/22/2005	COOKED	2	5	HSM	27	7.74	6.19	7.6
9/18/2005	COOKED	3	0	CON	10	10.31	10.53	10.66
9/18/2005	COOKED	3	0	BAT	10	8.21	7.87	9.22
9/18/2005	COOKED	3	0	ROS	10	8.04	8.34	9
9/18/2005	COOKED	3	0	LSM	10	6.3	6.54	6.13
9/18/2005	COOKED	3	0	MSM	10	5.47	5.97	5.87
9/18/2005	COOKED	3	0	HSM	10	6.99	8.13	6.98
9/18/2005	COOKED	3	0	CON	27	4.83	6.06	4.61
9/18/2005	COOKED	3	0	BAT	27	5	4.61	6.43
9/18/2005	COOKED	3	0	ROS	27	4.71	5.56	5.16
9/18/2005	COOKED	3	0	LSM	27	4	5.26	5.19
9/18/2005	COOKED	3	0	MSM	27	4.63	4.95	4.94
9/18/2005	COOKED	3	0	HSM	27	6.2	5.56	4.76
9/19/2005	COOKED	3	1	CON	10	7.86	7.41	8.62
9/19/2005	COOKED	3	1	BAT	10	8.29	8.93	9.36
9/19/2005	COOKED	3	1	ROS	10	7.76	8.07	9.6
9/19/2005	COOKED	3	1	LSM	10	7.81	7.41	7.62
9/19/2005	COOKED	3	1	MSM	10	6.71	6.58	7.31
9/19/2005	COOKED	3	1	HSM	10	6.25	6.94	7.42

Table B-12. Continued

Date	CON	Rep	Day	Trt	Fat	a*1	a*2	a*3
9/19/2005	COOKED	3	1	CON	27	5.36	4.92	4.84
9/19/2005	COOKED	3	1	BAT	27	5.36	5.05	4.8
9/19/2005	COOKED	3	1	ROS	27	5.73	5.38	6.14
9/19/2005	COOKED	3	1	LSM	27	4.56	4.41	5.58
9/19/2005	COOKED	3	1	MSM	27	5.58	6.72	5.59
9/19/2005	COOKED	3	1	HSM	27	4.9	5.33	5.24
9/21/2005	COOKED	3	3	CON	10	8.4	9.7	9.5
9/21/2005	COOKED	3	3	BAT	10	8.12	8.51	8.8
9/21/2005	COOKED	3	3	ROS	10	6.63	8.06	7.5
9/21/2005	COOKED	3	3	LSM	10	5.88	7.88	6.59
9/21/2005	COOKED	3	3	MSM	10	7.23	7.21	9.06
9/21/2005	COOKED	3	3	HSM	10	7.66	8.11	8.24
9/21/2005	COOKED	3	3	CON	27	7.25	5.39	5.02
9/21/2005	COOKED	3	3	BAT	27	5.01	6.36	5.55
9/21/2005	COOKED	3	3	ROS	27	6.53	9.41	6.71
9/21/2005	COOKED	3	3	LSM	27	6.65	5.45	5.89
9/21/2005	COOKED	3	3	MSM	27	5.73	5.05	6.6
9/21/2005	COOKED	3	3	HSM	27	5.74	5.26	7.26
9/29/2005	COOKED	3	5	CON	10	9.68	9.89	10.23
9/29/2005	COOKED	3	5	BAT	10	10.04	10.3	10.53
9/29/2005	COOKED	3	5	ROS	10	8.74	8.16	8.39
9/29/2005	COOKED	3	5	LSM	10	9.23	9.94	9.41
9/29/2005	COOKED	3	5	MSM	10	8.98	8.16	9.74
9/29/2005	COOKED	3	5	HSM	10	8.37	7.91	8.48
9/29/2005	COOKED	3	5	CON	27	7.55	7.15	7.4
9/29/2005	COOKED	3	5	BAT	27	7.56	7.69	7.04
9/29/2005	COOKED	3	5	ROS	27	6.2	5.71	6.27
9/29/2005	COOKED	3	5	LSM	27	7.11	7.5	7.92
9/29/2005	COOKED	3	5	MSM	27	5.75	5.77	6.52
9/29/2005	COOKED	3	5	HSM	27	7.14	6.86	6.22

Table B-13. Raw b* (yellowness) data table of the cooked gound beef patties

Date	CON	Rep	Day	Trt	Fat	b*1	b*2	b*3
7/10/2005	COOKED	1	0	CON	10	9.65	10.51	12.42
7/10/2005	COOKED	1	0	BAT	10	11.66	9.57	10.71
7/10/2005	COOKED	1	0	ROS	10	11.47	12.6	11.4
7/10/2005	COOKED	1	0	LSM	10	12.83	10.69	9.48
7/10/2005	COOKED	1	0	MSM	10	9.63	13.62	12.53
7/10/2005	COOKED	1	0	HSM	10	8.01	8.62	6.78
7/10/2005	COOKED	1	0	CON	27	9.19	7.22	9.87
7/10/2005	COOKED	1	0	BAT	27	5.11	5.4	6.44
7/10/2005	COOKED	1	0	ROS	27	5.34	6.34	5.91
7/10/2005	COOKED	1	0	LSM	27	5.46	7.01	8.48
7/10/2005	COOKED	1	0	MSM	27	6.29	6.94	4.78
7/10/2005	COOKED	1	0	HSM	27	6.22	7.93	6.13
7/11/2005	COOKED	1	1	CON	10	10.15	10.63	10.64
7/11/2005	COOKED	1	1	BAT	10	9.03	7.92	9.56
7/11/2005	COOKED	1	1	ROS	10	11.38	9.45	9.7
7/11/2005	COOKED	1	1	LSM	10	9.16	8.63	9.6
7/11/2005	COOKED	1	1	MSM	10	7.25	8.57	8.5
7/11/2005	COOKED	1	1	HSM	10	7.71	8.31	8.56
7/11/2005	COOKED	1	1	CON	27	9.46	7.75	9.17
7/11/2005	COOKED	1	1	BAT	27	9.53	8.64	8.48
7/11/2005	COOKED	1	1	ROS	27	9.91	10.65	11.04
7/11/2005	COOKED	1	1	LSM	27	7.33	9.03	7.97
7/11/2005	COOKED	1	1	MSM	27	12.28	8.73	8.16
7/11/2005	COOKED	1	1	HSM	27	8.33	7.12	7.08
7/13/2005	COOKED	1	3	CON	10	11.04	10.99	10.37
7/13/2005	COOKED	1	3	BAT	10	9.1	9.15	10.22
7/13/2005	COOKED	1	3	ROS	10	10.33	9.11	10.69
7/13/2005	COOKED	1	3	LSM	10	9.28	9.1	8.83
7/13/2005	COOKED	1	3	MSM	10	9.18	7.68	8.44
7/13/2005	COOKED	1	3	HSM	10	8.48	7.12	7.33
7/13/2005	COOKED	1	3	CON	27	8.6	7.99	6.71
7/13/2005	COOKED	1	3	BAT	27	10.81	9.63	11.87
7/13/2005	COOKED	1	3	ROS	27	7.96	10.36	10.03
7/13/2005	COOKED	1	3	LSM	27	9.38	9.04	8.34
7/13/2005	COOKED	1	3	MSM	27	7.39	7.93	6.81
7/13/2005	COOKED	1	3	HSM	27	8.68	7.83	7.59
7/15/2005	COOKED	1	5	CON	10	9.58	9.06	8.84
7/15/2005	COOKED	1	5	BAT	10	10.29	9.67	8.6

Table B-13. Continued

Date	CON	Rep	Day	Trt	Fat	b*1	b*2	b*3
7/15/2005	COOKED	1	5	ROS	10	10.28	10.69	10.88
7/15/2005	COOKED	1	5	LSM	10	9.31	8.45	8.87
7/15/2005	COOKED	1	5	MSM	10	8.99	8.34	8.54
7/15/2005	COOKED	1	5	HSM	10	8.72	7.47	8.46
7/15/2005	COOKED	1	5	CON	27	9.39	8.05	9.42
7/15/2005	COOKED	1	5	BAT	27	9.48	8.36	8.37
7/15/2005	COOKED	1	5	ROS	27	8.6	9.07	9.67
7/15/2005	COOKED	1	5	LSM	27	9.15	9.25	9.79
7/15/2005	COOKED	1	5	MSM	27	8.82	8.7	9.28
7/15/2005	COOKED	1	5	HSM	27	7.36	7.57	8.07
7/17/2005	COOKED	2	0	CON	10	9.92	7.82	8.25
7/17/2005	COOKED	2	0	BAT	10	9.82	10.24	10.59
7/17/2005	COOKED	2	0	ROS	10	8.06	9.84	9.32
7/17/2005	COOKED	2	0	LSM	10	8.32	7.81	7.54
7/17/2005	COOKED	2	0	MSM	10	6.32	6.04	8
7/17/2005	COOKED	2	0	HSM	10	6.39	7.77	6.22
7/17/2005	COOKED	2	0	CON	27	6.31	7.84	7.33
7/17/2005	COOKED	2	0	BAT	27	7.25	8.86	8.39
7/17/2005	COOKED	2	0	ROS	27	8.4	9.6	8.59
7/17/2005	COOKED	2	0	LSM	27	8.01	9.47	10.19
7/17/2005	COOKED	2	0	MSM	27	4.69	6.34	7.64
7/17/2005	COOKED	2	0	HSM	27	7.59	8.48	8.11
7/18/2005	COOKED	2	1	CON	10	10.87	11.1	10.47
7/18/2005	COOKED	2	1	BAT	10	9.38	8.34	8.73
7/18/2005	COOKED	2	1	ROS	10	9.72	9.5	10.59
7/18/2005	COOKED	2	1	LSM	10	8.65	9.2	9.62
7/18/2005	COOKED	2	1	MSM	10	7.04	7.59	8.75
7/18/2005	COOKED	2	1	HSM	10	7.62	7.8	7.31
7/18/2005	COOKED	2	1	CON	27	9.59	8.53	9.54
7/18/2005	COOKED	2	1	BAT	27	9.72	9.32	9.73
7/18/2005	COOKED	2	1	ROS	27	9.14	8.55	10.49
7/18/2005	COOKED	2	1	LSM	27	9.69	9.62	11.54
7/18/2005	COOKED	2	1	MSM	27	8.4	9.59	9.9
7/18/2005	COOKED	2	1	HSM	27	8.89	8.71	8.94
7/20/2005	COOKED	2	3	CON	10	9.45	10.71	10.07
7/20/2005	COOKED	2	3	BAT	10	8.68	7.65	7.94
7/20/2005	COOKED	2	3	ROS	10	9.25	9.04	8.53
7/20/2005	COOKED	2	3	LSM	10	8.28	7.9	8.55

Table B-13. Continued

Date	CON	Rep	Day	Trt	Fat	b*1	b*2	b*3
7/20/2005	COOKED	2	3	MSM	10	8.5	7.04	8.43
7/20/2005	COOKED	2	3	HSM	10	7.99	7.93	7.57
7/20/2005	COOKED	2	3	CON	27	9.48	9.3	10.08
7/20/2005	COOKED	2	3	BAT	27	10.03	10.92	8.12
7/20/2005	COOKED	2	3	ROS	27	10.84	11.01	11.75
7/20/2005	COOKED	2	3	LSM	27	10.81	8.44	8.81
7/20/2005	COOKED	2	3	MSM	27	7.92	9.74	8.66
7/20/2005	COOKED	2	3	HSM	27	9	9.27	8.79
7/22/2005	COOKED	2	5	CON	10	8.74	8.03	9.74
7/22/2005	COOKED	2	5	BAT	10	9.62	9.09	9.59
7/22/2005	COOKED	2	5	ROS	10	9.53	8.85	9.83
7/22/2005	COOKED	2	5	LSM	10	8.4	9.25	9.14
7/22/2005	COOKED	2	5	MSM	10	8.15	8.74	8.71
7/22/2005	COOKED	2	5	HSM	10	7.51	8.62	7.76
7/22/2005	COOKED	2	5	CON	27	10.59	11.02	10.36
7/22/2005	COOKED	2	5	BAT	27	9.98	7.22	9.74
7/22/2005	COOKED	2	5	ROS	27	10.39	10.8	11.43
7/22/2005	COOKED	2	5	LSM	27	9.38	11.19	8.57
7/22/2005	COOKED	2	5	MSM	27	7.65	9.81	9.39
7/22/2005	COOKED	2	5	HSM	27	8.36	9.13	8.61
9/18/2005	COOKED	3	0	CON	10	7.53	8.44	11.9
9/18/2005	COOKED	3	0	BAT	10	7.96	6.07	8.31
9/18/2005	COOKED	3	0	ROS	10	7.13	5.86	7.37
9/18/2005	COOKED	3	0	LSM	10	4.31	5.29	3.95
9/18/2005	COOKED	3	0	MSM	10	4.96	4.83	5.84
9/18/2005	COOKED	3	0	HSM	10	6.18	7.17	6.16
9/18/2005	COOKED	3	0	CON	27	5.28	7.09	2.76
9/18/2005	COOKED	3	0	BAT	27	4.92	4.55	4.77
9/18/2005	COOKED	3	0	ROS	27	3.74	5.56	5.27
9/18/2005	COOKED	3	0	LSM	27	4	5.25	4.91
9/18/2005	COOKED	3	0	MSM	27	4.98	6.53	3.86
9/18/2005	COOKED	3	0	HSM	27	6.13	4.74	3.94
9/19/2005	COOKED	3	1	CON	10	6.31	7.27	8.29
9/19/2005	COOKED	3	1	BAT	10	6.13	7.07	8.11
9/19/2005	COOKED	3	1	ROS	10	6.01	6.41	7.39
9/19/2005	COOKED	3	1	LSM	10	7.41	6.01	7.02
9/19/2005	COOKED	3	1	MSM	10	5.21	6.72	7.44
9/19/2005	COOKED	3	1	HSM	10	6.15	7.03	6.28

Table B-13. Continued

Date	CON	Rep	Day	Trt	Fat	b*1	b*2	b*3
9/19/2005	COOKED	3	1	CON	27	4.31	3.93	4.42
9/19/2005	COOKED	3	1	BAT	27	4.91	6.97	4.87
9/19/2005	COOKED	3	1	ROS	27	7.16	7.37	8.09
9/19/2005	COOKED	3	1	LSM	27	5.86	8.15	6.27
9/19/2005	COOKED	3	1	MSM	27	8.48	8.66	6.82
9/19/2005	COOKED	3	1	HSM	27	5.64	5.71	5.44
9/21/2005	COOKED	3	3	CON	10	8.1	8.5	8.71
9/21/2005	COOKED	3	3	BAT	10	6.85	8.32	8.87
9/21/2005	COOKED	3	3	ROS	10	7.14	7.8	7.73
9/21/2005	COOKED	3	3	LSM	10	6.16	8.78	6.7
9/21/2005	COOKED	3	3	MSM	10	6.2	6.52	7.32
9/21/2005	COOKED	3	3	HSM	10	6.78	7.22	7.08
9/21/2005	COOKED	3	3	CON	27	6.24	9.64	11.29
9/21/2005	COOKED	3	3	BAT	27	7.51	5.63	10.45
9/21/2005	COOKED	3	3	ROS	27	5.85	8.49	6.25
9/21/2005	COOKED	3	3	LSM	27	4.92	6.41	8.06
9/21/2005	COOKED	3	3	MSM	27	6.18	7.94	8.2
9/21/2005	COOKED	3	3	HSM	27	5.75	8.1	5.93
9/29/2005	COOKED	3	5	CON	10	8.47	9.77	9.06
9/29/2005	COOKED	3	5	BAT	10	8.36	8.28	9.75
9/29/2005	COOKED	3	5	ROS	10	8.64	9.24	9.14
9/29/2005	COOKED	3	5	LSM	10	8.54	8.26	8.45
9/29/2005	COOKED	3	5	MSM	10	7.38	9.23	9.01
9/29/2005	COOKED	3	5	HSM	10	7.9	7.55	7.86
9/29/2005	COOKED	3	5	CON	27	9.46	8.61	10.95
9/29/2005	COOKED	3	5	BAT	27	11.57	14.06	11.98
9/29/2005	COOKED	3	5	ROS	27	11.38	12.05	14.03
9/29/2005	COOKED	3	5	LSM	27	10.66	11.46	10.79
9/29/2005	COOKED	3	5	MSM	27	12.06	12.39	10.65
9/29/2005	COOKED	3	5	HSM	27	9.18	9.38	8.64

Table B-14. Raw TBARS data table of the cooked gound beef patties

Date	CON	Rep	Day	Trt	Fat	TR1	TR2	TR3	TR4
7/10/2005	COOKED	1	0	CON	10	0.151	0.15	0.161	0.158
7/10/2005	COOKED	1	0	BAT	10	0.079	0.076	0.078	0.079
7/10/2005	COOKED	1	0	ROS	10	0.076	0.076	0.07	0.07
7/10/2005	COOKED	1	0	LSM	10	0.091	0.093	0.102	0.105
7/10/2005	COOKED	1	0	MSM	10	0.077	0.075	0.073	0.077
7/10/2005	COOKED	1	0	HSM	10	0.079	0.073	0.071	0.071
7/10/2005	COOKED	1	0	CON	27	0.141	0.144	0.141	0.136
7/10/2005	COOKED	1	0	BAT	27	0.071	0.073	0.071	0.071
7/10/2005	COOKED	1	0	ROS	27	0.09	0.089	0.086	0.081
7/10/2005	COOKED	1	0	LSM	27	0.089	0.083	0.078	0.075
7/10/2005	COOKED	1	0	MSM	27	0.072	0.072	0.076	0.074
7/10/2005	COOKED	1	0	HSM	27	0.057	0.057	0.056	0.056
7/11/2005	COOKED	1	1	CON	10	0.278	0.27	0.34	0.338
7/11/2005	COOKED	1	1	BAT	10	0.091	0.092	0.091	0.089
7/11/2005	COOKED	1	1	ROS	10	0.132	0.13	0.15	0.149
7/11/2005	COOKED	1	1	LSM	10	0.124	0.123	0.114	0.112
7/11/2005	COOKED	1	1	MSM	10	0.08	0.076	0.068	0.067
7/11/2005	COOKED	1	1	HSM	10	0.069	0.07	0.079	0.079
7/11/2005	COOKED	1	1	CON	27	0.465	0.464	0.377	0.377
7/11/2005	COOKED	1	1	BAT	27	0.141	0.141	0.133	0.132
7/11/2005	COOKED	1	1	ROS	27	0.231	0.23	0.184	0.181
7/11/2005	COOKED	1	1	LSM	27	0.113	0.111	0.101	0.102
7/11/2005	COOKED	1	1	MSM	27	0.064	0.062	0.059	0.06
7/11/2005	COOKED	1	1	HSM	27	0.063	0.063	0.054	0.053
7/13/2005	COOKED	1	3	CON	10	0.669	0.661	0.425	0.427
7/13/2005	COOKED	1	3	BAT	10	0.102	0.1	0.102	0.101
7/13/2005	COOKED	1	3	ROS	10	0.295	0.296	0.357	0.356
7/13/2005	COOKED	1	3	LSM	10	0.167	0.167	0.179	0.178
7/13/2005	COOKED	1	3	MSM	10	0.078	0.079	0.082	0.08
7/13/2005	COOKED	1	3	HSM	10	0.075	0.074	0.089	0.096
7/13/2005	COOKED	1	3	CON	27	0.645	0.645	0.734	0.736
7/13/2005	COOKED	1	3	BAT	27	0.148	0.145	0.16	0.164
7/13/2005	COOKED	1	3	ROS	27	0.364	0.367	0.266	0.267
7/13/2005	COOKED	1	3	LSM	27	0.149	0.151	0.138	0.14
7/13/2005	COOKED	1	3	MSM	27	0.068	0.072	0.06	0.067
7/13/2005	COOKED	1	3	HSM	27	0.051	0.054	0.054	0.059
7/15/2005	COOKED	1	5	CON	10	0.914	0.916	1.02	1.011
7/15/2005	COOKED	1	5	BAT	10	0.115	0.118	0.108	0.109

Table B-14. Continued

Date	CON	Rep	Day	Trt	Fat	TR1	TR2	TR3	TR4
7/15/2005	COOKED	1	5	ROS	10	0.369	0.372	0.409	0.411
7/15/2005	COOKED	1	5	LSM	10	0.22	0.222	0.236	0.238
7/15/2005	COOKED	1	5	MSM	10	0.095	0.093	0.08	0.079
7/15/2005	COOKED	1	5	HSM	10	0.079	0.081	0.078	0.073
7/15/2005	COOKED	1	5	CON	27	1.004	1.006	1.011	1.02
7/15/2005	COOKED	1	5	BAT	27	0.181	0.174	0.198	0.199
7/15/2005	COOKED	1	5	ROS	27	0.538	0.54	0.55	0.55
7/15/2005	COOKED	1	5	LSM	27	0.203	0.206	0.212	0.212
7/15/2005	COOKED	1	5	MSM	27	0.077	0.077	0.07	0.072
7/15/2005	COOKED	1	5	HSM	27	0.059	0.06	0.066	0.068
7/17/2005	COOKED	2	0	CON	10	0.094	0.095	0.129	0.13
7/17/2005	COOKED	2	0	BAT	10	0.05	0.052	0.04	0.033
7/17/2005	COOKED	2	0	ROS	10	0.052	0.054	0.054	0.055
7/17/2005	COOKED	2	0	LSM	10	0.071	0.069	0.074	0.074
7/17/2005	COOKED	2	0	MSM	10	0.031	0.034	0.04	0.039
7/17/2005	COOKED	2	0	HSM	10	0.048	0.044	0.038	0.038
7/17/2005	COOKED	2	0	CON	27	0.2	0.201	0.195	0.194
7/17/2005	COOKED	2	0	BAT	27	0.102	0.107	0.096	0.098
7/17/2005	COOKED	2	0	ROS	27	0.087	0.088	0.083	0.083
7/17/2005	COOKED	2	0	LSM	27	0.1	0.098	0.097	0.097
7/17/2005	COOKED	2	0	MSM	27	0.088	0.087	0.089	0.09
7/17/2005	COOKED	2	0	HSM	27	0.078	0.081	0.07	0.08
7/18/2005	COOKED	2	1	CON	10	0.381	0.383	0.303	0.304
7/18/2005	COOKED	2	1	BAT	10	0.038	0.038	0.039	0.038
7/18/2005	COOKED	2	1	ROS	10	0.131	0.131	0.184	0.182
7/18/2005	COOKED	2	1	LSM	10	0.106	0.109	0.11	0.109
7/18/2005	COOKED	2	1	MSM	10	0.045	0.046	0.047	0.045
7/18/2005	COOKED	2	1	HSM	10	0.043	0.042	0.043	0.04
7/18/2005	COOKED	2	1	CON	27	0.346	0.349	0.327	0.325
7/18/2005	COOKED	2	1	BAT	27	.	.	.	.
7/18/2005	COOKED	2	1	ROS	27	0.208	0.207	0.223	0.223
7/18/2005	COOKED	2	1	LSM	27	0.109	0.102	0.135	0.134
7/18/2005	COOKED	2	1	MSM	27	0.085	0.084	0.085	0.084
7/18/2005	COOKED	2	1	HSM	27	0.114	0.098	0.076	0.075
7/20/2005	COOKED	2	3	CON	10	0.617	0.615	0.732	0.729
7/20/2005	COOKED	2	3	BAT	10	0.047	0.048	0.048	0.045
7/20/2005	COOKED	2	3	ROS	10	0.366	0.369	0.382	0.381
7/20/2005	COOKED	2	3	LSM	10	0.173	0.173	0.143	0.143

Table B-14. Continued

Date	CON	Rep	Day	Trt	Fat	TR1	TR2	TR3	TR4
7/20/2005	COOKED	2	3	MSM	10	0.054	0.051	0.079	0.085
7/20/2005	COOKED	2	3	HSM	10	0.05	0.049	0.049	0.051
7/20/2005	COOKED	2	3	CON	27	0.559	0.56	0.595	0.594
7/20/2005	COOKED	2	3	BAT	27	0.116	0.117	0.13	0.129
7/20/2005	COOKED	2	3	ROS	27	0.388	0.384	0.332	0.33
7/20/2005	COOKED	2	3	LSM	27	0.132	0.129	0.158	0.163
7/20/2005	COOKED	2	3	MSM	27	0.103	0.104	0.099	0.1
7/20/2005	COOKED	2	3	HSM	27	0.086	0.089	0.074	0.073
7/22/2005	COOKED	2	5	CON	10	0.859	0.861	0.831	0.833
7/22/2005	COOKED	2	5	BAT	10	0.045	0.046	0.05	0.051
7/22/2005	COOKED	2	5	ROS	10	0.436	0.44	0.543	0.547
7/22/2005	COOKED	2	5	LSM	10	0.203	0.207	0.199	0.201
7/22/2005	COOKED	2	5	MSM	10	0.069	0.072	0.068	0.071
7/22/2005	COOKED	2	5	HSM	10	0.059	0.06	0.047	0.05
7/22/2005	COOKED	2	5	CON	27	0.739	0.731	0.701	0.7
7/22/2005	COOKED	2	5	BAT	27	0.129	0.128	0.122	0.127
7/22/2005	COOKED	2	5	ROS	27	0.458	0.459	0.464	0.462
7/22/2005	COOKED	2	5	LSM	27	0.167	0.172	0.16	0.162
7/22/2005	COOKED	2	5	MSM	27	0.09	0.088	0.084	0.084
7/22/2005	COOKED	2	5	HSM	27	0.072	0.076	0.069	0.069
9/18/2005	COOKED	3	0	CON	10	0.256	0.216	0.187	0.189
9/18/2005	COOKED	3	0	BAT	10	0.12	0.119	0.128	0.129
9/18/2005	COOKED	3	0	ROS	10	0.112	0.115	0.119	0.119
9/18/2005	COOKED	3	0	LSM	10	0.133	0.132	0.123	0.123
9/18/2005	COOKED	3	0	MSM	10	0.152	0.152	0.167	0.166
9/18/2005	COOKED	3	0	HSM	10	0.108	0.108	0.121	0.12
9/18/2005	COOKED	3	0	CON	27	0.14	0.141	0.108	0.105
9/18/2005	COOKED	3	0	BAT	27	0.071	0.072	0.067	0.068
9/18/2005	COOKED	3	0	ROS	27	0.079	0.082	0.082	0.083
9/18/2005	COOKED	3	0	LSM	27	0.091	0.087	0.093	0.095
9/18/2005	COOKED	3	0	MSM	27	0.073	0.071	0.068	0.071
9/18/2005	COOKED	3	0	HSM	27	0.075	0.078	0.072	0.072
9/19/2005	COOKED	3	1	CON	10	0.503	0.505	0.48	0.475
9/19/2005	COOKED	3	1	BAT	10	0.147	0.146	0.127	0.127
9/19/2005	COOKED	3	1	ROS	10	0.241	0.24	0.262	0.266
9/19/2005	COOKED	3	1	LSM	10	0.223	0.232	0.218	0.217
9/19/2005	COOKED	3	1	MSM	10	0.15	0.151	0.151	0.151
9/19/2005	COOKED	3	1	HSM	10	0.108	0.108	0.107	0.108

Table B-14. Continued

Date	CON	Rep	Day	Trt	Fat	TR1	TR2	TR3	TR4
9/19/2005	COOKED	3	1	CON	27	0.666	0.668	0.574	0.578
9/19/2005	COOKED	3	1	BAT	27	0.101	0.1	0.091	0.094
9/19/2005	COOKED	3	1	ROS	27	0.271	0.275	0.31	0.315
9/19/2005	COOKED	3	1	LSM	27	0.132	0.132	0.114	0.116
9/19/2005	COOKED	3	1	MSM	27	0.053	0.058	0.042	0.043
9/19/2005	COOKED	3	1	HSM	27	0.068	0.068	0.073	0.078
9/21/2005	COOKED	3	3	CON	10	0.751	0.752	0.82	0.821
9/21/2005	COOKED	3	3	BAT	10	0.122	0.122	0.114	0.116
9/21/2005	COOKED	3	3	ROS	10	0.629	0.629	0.7	0.708
9/21/2005	COOKED	3	3	LSM	10	0.396	0.398	0.247	0.251
9/21/2005	COOKED	3	3	MSM	10	0.173	0.169	0.175	0.178
9/21/2005	COOKED	3	3	HSM	10	0.117	0.118	0.122	0.124
9/21/2005	COOKED	3	3	CON	27	1.02	1.028	0.987	0.97
9/21/2005	COOKED	3	3	BAT	27	0.099	0.1	0.1	0.1
9/21/2005	COOKED	3	3	ROS	27	0.44	0.441	0.461	0.456
9/21/2005	COOKED	3	3	LSM	27	0.199	0.203	0.188	0.188
9/21/2005	COOKED	3	3	MSM	27	0.081	0.08	0.069	0.07
9/21/2005	COOKED	3	3	HSM	27	0.069	0.07	0.082	0.08
9/29/2005	COOKED	3	5	CON	10	0.891	0.894	1.219	1.221
9/29/2005	COOKED	3	5	BAT	10	0.114	0.115	0.118	0.119
9/29/2005	COOKED	3	5	ROS	10	0.613	0.611	0.851	0.852
9/29/2005	COOKED	3	5	LSM	10	0.553	0.553	0.525	0.525
9/29/2005	COOKED	3	5	MSM	10	0.176	0.177	0.167	0.166
9/29/2005	COOKED	3	5	HSM	10	0.1	0.101	0.098	0.099
9/29/2005	COOKED	3	5	CON	27	1.082	1.087	1.193	1.194
9/29/2005	COOKED	3	5	BAT	27	0.101	0.103	0.086	0.085
9/29/2005	COOKED	3	5	ROS	27	0.65	0.649	0.708	0.708
9/29/2005	COOKED	3	5	LSM	27	0.264	0.262	0.215	0.205
9/29/2005	COOKED	3	5	MSM	27	0.071	0.07	0.071	0.073
9/29/2005	COOKED	3	5	HSM	27	0.056	0.06	0.057	0.056

Table B-15. Raw non-heme iron spectrum data table of the cooked gound beef patties

Date	CON	Rep	Day	Trt	Fat	NH1	NH2	NH3	NH4
7/10/2005	RAW	1	0	CON	10	0.099	0.082	0.091	0.091
7/10/2005	RAW	1	0	BAT	10	0.098	0.098	0.099	0.1
7/10/2005	RAW	1	0	ROS	10	0.113	0.114	0.115	0.114
7/10/2005	RAW	1	0	LSM	10	0.13	0.128	0.132	0.133
7/10/2005	RAW	1	0	MSM	10	0.134	0.134	0.143	0.141
7/10/2005	RAW	1	0	HSM	10	0.163	0.154	0.168	0.158
7/10/2005	RAW	1	0	CON	27	0.07	0.062	0.063	0.063
7/10/2005	RAW	1	0	BAT	27	0.115	0.112	0.177	0.196
7/10/2005	RAW	1	0	ROS	27	0.08	0.079	0.085	0.085
7/10/2005	RAW	1	0	LSM	27	0.118	0.108	0.158	0.156
7/10/2005	RAW	1	0	MSM	27	0.173	0.171	0.145	0.143
7/10/2005	RAW	1	0	HSM	27	0.183	0.182	0.193	0.193
7/10/2005	COOKED	1	0	CON	10	0.224	0.215	0.205	0.201
7/10/2005	COOKED	1	0	BAT	10	0.135	0.127	0.128	0.127
7/10/2005	COOKED	1	0	ROS	10	0.153	0.15	0.146	0.135
7/10/2005	COOKED	1	0	LSM	10	0.189	0.182	0.178	0.174
7/10/2005	COOKED	1	0	MSM	10	0.199	0.121	0.202	0.192
7/10/2005	COOKED	1	0	HSM	10	0.248	0.243	0.256	0.253
7/10/2005	COOKED	1	0	CON	27	0.149	0.151	0.151	0.148
7/10/2005	COOKED	1	0	BAT	27	0.141	0.135	0.142	0.141
7/10/2005	COOKED	1	0	ROS	27	0.15	0.149	0.156	0.15
7/10/2005	COOKED	1	0	LSM	27	0.175	0.172	0.16	0.169
7/10/2005	COOKED	1	0	MSM	27	0.198	0.2	0.205	0.205
7/10/2005	COOKED	1	0	HSM	27	0.264	0.264	0.265	0.257
7/15/2005	COOKED	1	5	CON	10	0.181	0.168	0.172	0.169
7/15/2005	COOKED	1	5	BAT	10	0.111	0.11	0.116	0.116
7/15/2005	COOKED	1	5	ROS	10	0.157	0.147	0.161	0.153
7/15/2005	COOKED	1	5	LSM	10	0.182	0.181	0.191	0.182
7/15/2005	COOKED	1	5	MSM	10	0.224	0.217	0.23	0.213
7/15/2005	COOKED	1	5	HSM	10	0.207	0.2	0.206	0.205
7/15/2005	COOKED	1	5	CON	27	0.187	0.187	0.199	0.198
7/15/2005	COOKED	1	5	BAT	27	0.159	0.155	0.165	0.157
7/15/2005	COOKED	1	5	ROS	27	0.16	0.16	0.164	0.169
7/15/2005	COOKED	1	5	LSM	27	0.299	0.297	0.258	0.259
7/15/2005	COOKED	1	5	MSM	27	0.196	0.193	0.193	0.191
7/15/2005	COOKED	1	5	HSM	27	0.374	0.367	0.388	0.393
7/17/2005	RAW	2	0	CON	10	0.064	0.064	0.064	0.066
7/17/2005	RAW	2	0	BAT	10	0.075	0.073	0.073	0.072

Table B-15. Continued

Date	CON	Rep	Day	Trt	Fat	NH1	NH2	NH3	NH4
7/17/2005	RAW	2	0	ROS	10	0.058	0.058	0.062	0.062
7/17/2005	RAW	2	0	LSM	10	0.113	0.112	0.113	0.112
7/17/2005	RAW	2	0	MSM	10	0.115	0.115	0.123	0.123
7/17/2005	RAW	2	0	HSM	10	0.175	0.177	0.192	0.191
7/17/2005	RAW	2	0	CON	27	0.065	0.064	0.057	0.059
7/17/2005	RAW	2	0	BAT	27	0.08	0.079	0.087	0.087
7/17/2005	RAW	2	0	ROS	27	0.061	0.061	0.068	0.068
7/17/2005	RAW	2	0	LSM	27	0.09	0.082	0.098	0.098
7/17/2005	RAW	2	0	MSM	27	0.099	0.099	0.115	0.105
7/17/2005	RAW	2	0	HSM	27	0.137	0.136	0.15	0.146
7/17/2005	COOKED	2	0	CON	10	0.125	0.125	0.129	0.128
7/17/2005	COOKED	2	0	BAT	10	0.108	0.108	0.117	0.116
7/17/2005	COOKED	2	0	ROS	10	0.099	0.1	0.104	0.103
7/17/2005	COOKED	2	0	LSM	10	0.132	0.134	0.136	0.137
7/17/2005	COOKED	2	0	MSM	10	0.157	0.155	0.159	0.159
7/17/2005	COOKED	2	0	HSM	10	0.19	0.191	0.197	0.197
7/17/2005	COOKED	2	0	CON	27	0.102	0.102	0.105	0.103
7/17/2005	COOKED	2	0	BAT	27	0.123	0.117	0.128	0.125
7/17/2005	COOKED	2	0	ROS	27	0.121	0.121	0.14	0.142
7/17/2005	COOKED	2	0	LSM	27	0.167	0.167	0.176	0.176
7/17/2005	COOKED	2	0	MSM	27	0.237	0.237	0.227	0.227
7/17/2005	COOKED	2	0	HSM	27	0.248	0.247	0.246	0.249
7/22/2005	COOKED	2	5	CON	10	0.123	0.127	0.126	0.128
7/22/2005	COOKED	2	5	BAT	10	0.104	0.103	0.115	0.116
7/22/2005	COOKED	2	5	ROS	10	0.12	0.12	0.136	0.132
7/22/2005	COOKED	2	5	LSM	10	0.226	0.224	0.22	0.22
7/22/2005	COOKED	2	5	MSM	10	0.182	0.184	0.161	0.163
7/22/2005	COOKED	2	5	HSM	10	0.219	0.219	0.188	0.189
7/22/2005	COOKED	2	5	CON	27	0.134	0.132	0.132	0.132
7/22/2005	COOKED	2	5	BAT	27	0.128	0.128	0.146	0.147
7/22/2005	COOKED	2	5	ROS	27	0.174	0.173	0.15	0.151
7/22/2005	COOKED	2	5	LSM	27	0.212	0.209	0.218	0.213
7/22/2005	COOKED	2	5	MSM	27	0.215	0.216	0.219	0.217
7/22/2005	COOKED	2	5	HSM	27	0.253	0.257	0.259	0.259
9/18/2005	RAW	3	0	CON	10	0.06	0.062	0.061	0.064
9/18/2005	RAW	3	0	BAT	10	0.064	0.065	0.073	0.075
9/18/2005	RAW	3	0	ROS	10	0.099	0.096	0.07	0.07
9/18/2005	RAW	3	0	LSM	10	0.114	0.115	0.112	0.112

Table B-15. Continued

Date	CON	Rep	Day	Trt	Fat	NH1	NH2	NH3	NH4
9/18/2005	RAW	3	0	MSM	10	0.104	0.105	0.104	0.107
9/18/2005	RAW	3	0	HSM	10	0.398	0.405	0.404	0.403
9/18/2005	RAW	3	0	CON	27	0.062	0.06	0.056	0.058
9/18/2005	RAW	3	0	BAT	27	0.065	0.067	0.067	0.066
9/18/2005	RAW	3	0	ROS	27	0.086	0.086	0.092	0.093
9/18/2005	RAW	3	0	LSM	27	0.099	0.1	0.101	0.102
9/18/2005	RAW	3	0	MSM	27	0.107	0.108	0.107	0.108
9/18/2005	RAW	3	0	HSM	27	0.133	0.137	0.142	0.14
9/18/2005	COOKED	3	0	CON	10	0.166	0.165	0.162	0.163
9/18/2005	COOKED	3	0	BAT	10	0.13	0.129	0.13	0.132
9/18/2005	COOKED	3	0	ROS	10	0.112	0.111	0.112	0.11
9/18/2005	COOKED	3	0	LSM	10	0.165	0.166	0.173	0.173
9/18/2005	COOKED	3	0	MSM	10	0.19	0.189	0.193	0.193
9/18/2005	COOKED	3	0	HSM	10	0.224	0.224	0.223	0.223
9/18/2005	COOKED	3	0	CON	27	0.126	0.13	0.134	0.132
9/18/2005	COOKED	3	0	BAT	27	0.127	0.128	0.131	0.131
9/18/2005	COOKED	3	0	ROS	27	0.166	0.167	0.169	0.168
9/18/2005	COOKED	3	0	LSM	27	0.164	0.164	0.164	0.164
9/18/2005	COOKED	3	0	MSM	27	0.222	0.22	0.226	0.226
9/18/2005	COOKED	3	0	HSM	27	0.348	0.346	0.342	0.341
9/29/2005	COOKED	3	5	CON	10	0.18	0.177	0.177	0.175
9/29/2005	COOKED	3	5	BAT	10	0.132	0.134	0.129	0.128
9/29/2005	COOKED	3	5	ROS	10	0.161	0.16	0.158	0.155
9/29/2005	COOKED	3	5	LSM	10	0.145	0.144	0.147	0.147
9/29/2005	COOKED	3	5	MSM	10	0.197	0.198	0.201	0.198
9/29/2005	COOKED	3	5	HSM	10	0.211	0.211	0.212	0.211
9/29/2005	COOKED	3	5	CON	27	0.183	0.183	0.187	0.184
9/29/2005	COOKED	3	5	BAT	27	0.177	0.177	0.179	0.178
9/29/2005	COOKED	3	5	ROS	27	0.176	0.176	0.177	0.178
9/29/2005	COOKED	3	5	LSM	27	0.178	0.181	0.179	0.179
9/29/2005	COOKED	3	5	MSM	27	0.231	0.235	0.241	0.241
9/29/2005	COOKED	3	5	HSM	27	0.265	0.263	0.271	0.267

Table B-16. Raw non-heme iron blank data table of the cooked gound beef patties

Date	CON	Rep	Day	Trt	Fat	BK1	BK2	BK3	BK4
7/10/2005	RAW	1	0	CON	10	0.03	0.031	0.027	0.03
7/10/2005	RAW	1	0	BAT	10	0.027	0.026	0.024	0.021
7/10/2005	RAW	1	0	ROS	10	0.023	0.022	0.025	0.023
7/10/2005	RAW	1	0	LSM	10	0.047	0.043	0.044	0.043
7/10/2005	RAW	1	0	MSM	10	0.06	0.059	0.061	0.061
7/10/2005	RAW	1	0	HSM	10	0.085	0.089	0.083	0.086
7/10/2005	RAW	1	0	CON	27	0.013	0.012	0.014	0.013
7/10/2005	RAW	1	0	BAT	27	0.024	0.023	0.024	0.022
7/10/2005	RAW	1	0	ROS	27	0.025	0.023	0.024	0.023
7/10/2005	RAW	1	0	LSM	27	0.051	0.052	0.048	0.05
7/10/2005	RAW	1	0	MSM	27	0.061	0.062	0.064	0.064
7/10/2005	RAW	1	0	HSM	27	0.08	0.084	0.078	0.078
7/10/2005	COOKED	1	0	CON	10	0.032	0.034	0.03	0.033
7/10/2005	COOKED	1	0	BAT	10	0.033	0.032	0.033	0.033
7/10/2005	COOKED	1	0	ROS	10	0.036	0.037	0.037	0.037
7/10/2005	COOKED	1	0	LSM	10	0.059	0.057	0.056	0.055
7/10/2005	COOKED	1	0	MSM	10	0.079	0.081	0.078	0.079
7/10/2005	COOKED	1	0	HSM	10	0.098	0.166	0.097	0.101
7/10/2005	COOKED	1	0	CON	27	0.031	0.031	0.03	0.03
7/10/2005	COOKED	1	0	BAT	27	0.043	0.042	0.047	0.041
7/10/2005	COOKED	1	0	ROS	27	0.046	0.045	0.047	0.046
7/10/2005	COOKED	1	0	LSM	27	0.066	0.065	0.064	0.065
7/10/2005	COOKED	1	0	MSM	27	0.08	0.082	0.084	0.083
7/10/2005	COOKED	1	0	HSM	27	0.081	0.079	0.083	0.085
7/15/2005	COOKED	1	5	CON	10	0.044	0.041	0.04	0.041
7/15/2005	COOKED	1	5	BAT	10	0.036	0.034	0.037	0.036
7/15/2005	COOKED	1	5	ROS	10	0.047	0.047	0.043	0.046
7/15/2005	COOKED	1	5	LSM	10	0.06	0.059	0.062	0.061
7/15/2005	COOKED	1	5	MSM	10	0.083	0.088	0.082	0.083
7/15/2005	COOKED	1	5	HSM	10	0.1	0.103	0.097	0.102
7/15/2005	COOKED	1	5	CON	27	0.037	0.038	0.038	0.04
7/15/2005	COOKED	1	5	BAT	27	0.037	0.034	0.036	0.036
7/15/2005	COOKED	1	5	ROS	27	0.03	0.031	0.032	0.031
7/15/2005	COOKED	1	5	LSM	27	0.071	0.073	0.073	0.072
7/15/2005	COOKED	1	5	MSM	27	0.08	0.079	0.079	0.078
7/15/2005	COOKED	1	5	HSM	27	0.088	0.094	0.091	0.088
7/17/2005	RAW	2	0	CON	10	0.012	0.011	0.013	0.017
7/17/2005	RAW	2	0	BAT	10	0.018	0.019	0.02	0.019

Table B-16. Continued

Date	CON	Rep	Day	Trt	Fat	BK1	BK2	BK3	BK4
7/17/2005	RAW	2	0	ROS	10	0.016	0.016	0.014	0.016
7/17/2005	RAW	2	0	LSM	10	0.032	0.033	0.033	0.036
7/17/2005	RAW	2	0	MSM	10	0.041	0.043	0.043	0.043
7/17/2005	RAW	2	0	HSM	10	0.077	0.077	0.076	0.077
7/17/2005	RAW	2	0	CON	27	0.018	0.016	0.016	0.017
7/17/2005	RAW	2	0	BAT	27	0.02	0.02	0.019	0.022
7/17/2005	RAW	2	0	ROS	27	0.021	0.02	0.022	0.022
7/17/2005	RAW	2	0	LSM	27	0.037	0.038	0.036	0.037
7/17/2005	RAW	2	0	MSM	27	0.056	0.06	0.054	0.054
7/17/2005	RAW	2	0	HSM	27	0.089	0.086	0.09	0.084
7/17/2005	COOKED	2	0	CON	10	0.026	0.026	0.027	0.027
7/17/2005	COOKED	2	0	BAT	10	0.03	0.032	0.03	0.03
7/17/2005	COOKED	2	0	ROS	10	0.033	0.032	0.031	0.031
7/17/2005	COOKED	2	0	LSM	10	0.051	0.047	0.051	0.049
7/17/2005	COOKED	2	0	MSM	10	0.065	0.067	0.066	0.065
7/17/2005	COOKED	2	0	HSM	10	0.094	0.097	0.094	0.102
7/17/2005	COOKED	2	0	CON	27	0.037	0.034	0.036	0.034
7/17/2005	COOKED	2	0	BAT	27	0.033	0.033	0.036	0.033
7/17/2005	COOKED	2	0	ROS	27	0.027	0.025	0.025	0.026
7/17/2005	COOKED	2	0	LSM	27	0.06	0.061	0.061	0.062
7/17/2005	COOKED	2	0	MSM	27	0.087	0.086	0.088	0.09
7/17/2005	COOKED	2	0	HSM	27	0.123	0.129	0.112	0.121
7/22/2005	COOKED	2	5	CON	10	0.028	0.028	0.027	0.028
7/22/2005	COOKED	2	5	BAT	10	0.031	0.031	0.03	0.031
7/22/2005	COOKED	2	5	ROS	10	0.03	0.03	0.028	0.028
7/22/2005	COOKED	2	5	LSM	10	0.049	0.046	0.048	0.047
7/22/2005	COOKED	2	5	MSM	10	0.062	0.062	0.064	0.065
7/22/2005	COOKED	2	5	HSM	10	0.093	0.098	0.094	0.095
7/22/2005	COOKED	2	5	CON	27	0.036	0.038	0.037	0.038
7/22/2005	COOKED	2	5	BAT	27	0.036	0.036	0.035	0.036
7/22/2005	COOKED	2	5	ROS	27	0.028	0.028	0.028	0.029
7/22/2005	COOKED	2	5	LSM	27	0.067	0.068	0.069	0.065
7/22/2005	COOKED	2	5	MSM	27	0.081	0.087	0.084	0.084
7/22/2005	COOKED	2	5	HSM	27	0.115	0.119	0.119	0.245
9/18/2005	RAW	3	0	CON	10	0.007	0.008	0.007	0.008
9/18/2005	RAW	3	0	BAT	10	0.008	0.009	0.007	0.009
9/18/2005	RAW	3	0	ROS	10	0.008	0.007	0.008	0.007
9/18/2005	RAW	3	0	LSM	10	0.016	0.017	0.017	0.018

Table B-16. Continued

Date	CON	Rep	Day	Trt	Fat	BK1	BK2	BK3	BK4
9/18/2005	RAW	3	0	MSM	10	0.024	0.024	0.025	0.025
9/18/2005	RAW	3	0	HSM	10	0.051	0.051	0.051	0.049
9/18/2005	RAW	3	0	CON	27	0.01	0.011	0.01	0.009
9/18/2005	RAW	3	0	BAT	27	0.011	0.011	0.011	0.011
9/18/2005	RAW	3	0	ROS	27	0.012	0.011	0.011	0.012
9/18/2005	RAW	3	0	LSM	27	0.025	0.026	0.026	0.026
9/18/2005	RAW	3	0	MSM	27	0.036	0.034	0.035	0.035
9/18/2005	RAW	3	0	HSM	27	0.059	0.06	0.059	0.059
9/18/2005	COOKED	3	0	CON	10	0.018	0.018	0.019	0.019
9/18/2005	COOKED	3	0	BAT	10	0.023	0.021	0.02	0.02
9/18/2005	COOKED	3	0	ROS	10	0.018	0.019	0.017	0.018
9/18/2005	COOKED	3	0	LSM	10	0.029	0.028	0.028	0.026
9/18/2005	COOKED	3	0	MSM	10	0.046	0.047	0.047	0.047
9/18/2005	COOKED	3	0	HSM	10	0.071	0.07	0.07	0.071
9/18/2005	COOKED	3	0	CON	27	0.021	0.022	0.022	0.021
9/18/2005	COOKED	3	0	BAT	27	0.021	0.021	0.021	0.023
9/18/2005	COOKED	3	0	ROS	27	0.029	0.031	0.026	0.027
9/18/2005	COOKED	3	0	LSM	27	0.038	0.039	0.038	0.038
9/18/2005	COOKED	3	0	MSM	27	0.059	0.059	0.058	0.058
9/18/2005	COOKED	3	0	HSM	27	0.093	0.096	0.092	0.096
9/29/2005	COOKED	3	5	CON	10	0.016	0.017	0.018	0.018
9/29/2005	COOKED	3	5	BAT	10	0.02	0.02	0.021	0.02
9/29/2005	COOKED	3	5	ROS	10	0.02	0.019	0.019	0.02
9/29/2005	COOKED	3	5	LSM	10	0.034	0.034	0.035	0.032
9/29/2005	COOKED	3	5	MSM	10	0.048	0.048	0.048	0.053
9/29/2005	COOKED	3	5	HSM	10	0.07	0.07	0.069	0.07
9/29/2005	COOKED	3	5	CON	27	0.027	0.026	0.027	0.026
9/29/2005	COOKED	3	5	BAT	27	0.027	0.029	0.027	0.027
9/29/2005	COOKED	3	5	ROS	27	0.026	0.025	0.023	0.022
9/29/2005	COOKED	3	5	LSM	27	0.04	0.04	0.041	0.041
9/29/2005	COOKED	3	5	MSM	27	0.064	0.063	0.062	0.065
9/29/2005	COOKED	3	5	HSM	27	0.091	0.089	0.082	0.095

Table B-17. Raw non-heme iron dried sample weight data table of the cooked gound beef patties

Date	CON	Rep	Day	Trt	Fat	I-B1	I-B2	DWt1	DWt2
7/10/2005	RAW	1	0	CON	10	0.069	0.051	1.1425	1.1474
7/10/2005	RAW	1	0	BAT	10	0.071	0.072	1.1492	1.1506
7/10/2005	RAW	1	0	ROS	10	0.09	0.092	1.1375	1.1491
7/10/2005	RAW	1	0	LSM	10	0.083	0.085	1.1499	1.1461
7/10/2005	RAW	1	0	MSM	10	0.074	0.075	1.1499	1.1412
7/10/2005	RAW	1	0	HSM	10	0.078	0.065	1.1540	1.1380
7/10/2005	RAW	1	0	CON	27	0.057	0.05	1.1604	1.1496
7/10/2005	RAW	1	0	BAT	27	0.091	0.089	1.1475	1.1520
7/10/2005	RAW	1	0	ROS	27	0.055	0.056	1.1564	1.1507
7/10/2005	RAW	1	0	LSM	27	0.067	0.056	1.1431	1.1464
7/10/2005	RAW	1	0	MSM	27	0.112	0.109	1.1467	1.1525
7/10/2005	RAW	1	0	HSM	27	0.103	0.098	1.1561	1.1482
7/10/2005	COOKED	1	0	CON	10	0.192	0.181	1.1427	1.1368
7/10/2005	COOKED	1	0	BAT	10	0.102	0.095	1.1450	1.1610
7/10/2005	COOKED	1	0	ROS	10	0.117	0.113	1.1443	1.1340
7/10/2005	COOKED	1	0	LSM	10	0.13	0.125	1.1651	1.1596
7/10/2005	COOKED	1	0	MSM	10	0.12	0.04	1.1471	1.1419
7/10/2005	COOKED	1	0	HSM	10	0.15	0.077	1.1400	1.1398
7/10/2005	COOKED	1	0	CON	27	0.118	0.12	1.1459	1.14002
7/10/2005	COOKED	1	0	BAT	27	0.098	0.093	1.1565	1.15227
7/10/2005	COOKED	1	0	ROS	27	0.104	0.104	1.1468	1.13942
7/10/2005	COOKED	1	0	LSM	27	0.109	0.107	1.1380	1.1532
7/10/2005	COOKED	1	0	MSM	27	0.118	0.118	1.1649	1.1415
7/10/2005	COOKED	1	0	HSM	27	0.183	0.185	1.1534	1.1578
7/15/2005	COOKED	1	5	CON	10	0.137	0.127	1.1488	1.1445
7/15/2005	COOKED	1	5	BAT	10	0.075	0.076	1.1385	1.1548
7/15/2005	COOKED	1	5	ROS	10	0.11	0.1	1.1481	1.1548
7/15/2005	COOKED	1	5	LSM	10	0.122	0.122	1.1517	1.1490
7/15/2005	COOKED	1	5	MSM	10	0.141	0.129	1.1477	1.1490
7/15/2005	COOKED	1	5	HSM	10	0.107	0.097	1.1493	1.1394
7/15/2005	COOKED	1	5	CON	27	0.15	0.149	1.1554	1.1577
7/15/2005	COOKED	1	5	BAT	27	0.122	0.121	1.1341	1.1402
7/15/2005	COOKED	1	5	ROS	27	0.13	0.129	1.1397	1.1567
7/15/2005	COOKED	1	5	LSM	27	0.228	0.224	1.1495	1.15
7/15/2005	COOKED	1	5	MSM	27	0.116	0.114	1.1510	1.1542
7/15/2005	COOKED	1	5	HSM	27	0.286	0.273	1.1519	1.1447
7/17/2005	RAW	2	0	CON	10	0.052	0.053	1.1509	1.1596

Table B-17. Continued

Date	CON	Rep	Day	Trt	Fat	I-B1	I-B2	DWt1	DWt2
7/17/2005	RAW	2	0	BAT	10	0.057	0.054	1.1556	1.1540
7/17/2005	RAW	2	0	ROS	10	0.042	0.042	1.1508	1.1440
7/17/2005	RAW	2	0	LSM	10	0.081	0.079	1.1452	1.1394
7/17/2005	RAW	2	0	MSM	10	0.074	0.072	1.1474	1.1455
7/17/2005	RAW	2	0	HSM	10	0.098	0.1	1.1351	1.1423
7/17/2005	RAW	2	0	CON	27	0.047	0.048	1.1478	1.1389
7/17/2005	RAW	2	0	BAT	27	0.06	0.059	1.1472	1.1454
7/17/2005	RAW	2	0	ROS	27	0.04	0.041	1.1545	1.1529
7/17/2005	RAW	2	0	LSM	27	0.053	0.044	1.1517	1.1458
7/17/2005	RAW	2	0	MSM	27	0.043	0.039	1.1511	1.1463
7/17/2005	RAW	2	0	HSM	27	0.048	0.05	1.1526	1.1602
7/17/2005	COOKED	2	0	CON	10	0.099	0.099	1.1446	1.1513
7/17/2005	COOKED	2	0	BAT	10	0.078	0.076	1.1537	1.1434
7/17/2005	COOKED	2	0	ROS	10	0.066	0.068	1.1600	1.1460
7/17/2005	COOKED	2	0	LSM	10	0.081	0.087	1.1502	1.1515
7/17/2005	COOKED	2	0	MSM	10	0.092	0.088	1.1445	1.1533
7/17/2005	COOKED	2	0	HSM	10	0.096	0.094	1.1465	1.1591
7/17/2005	COOKED	2	0	CON	27	0.065	0.068	1.1479	1.1505
7/17/2005	COOKED	2	0	BAT	27	0.09	0.084	1.1518	1.1425
7/17/2005	COOKED	2	0	ROS	27	0.094	0.096	1.1562	1.1437
7/17/2005	COOKED	2	0	LSM	27	0.107	0.106	1.1543	1.1475
7/17/2005	COOKED	2	0	MSM	27	0.15	0.151	1.1548	1.1538
7/17/2005	COOKED	2	0	HSM	27	0.125	0.118	1.1447	1.1532
7/22/2005	COOKED	2	5	CON	10	0.095	0.099	1.1374	1.1580
7/22/2005	COOKED	2	5	BAT	10	0.073	0.072	1.1491	1.1405
7/22/2005	COOKED	2	5	ROS	10	0.09	0.09	1.1498	1.1395
7/22/2005	COOKED	2	5	LSM	10	0.177	0.178	1.1521	1.1587
7/22/2005	COOKED	2	5	MSM	10	0.12	0.122	1.1531	1.15337
7/22/2005	COOKED	2	5	HSM	10	0.126	0.121	1.1593	1.1574
7/22/2005	COOKED	2	5	CON	27	0.098	0.094	1.1524	1.1584
7/22/2005	COOKED	2	5	BAT	27	0.092	0.092	1.153	1.1526
7/22/2005	COOKED	2	5	ROS	27	0.146	0.145	1.1422	1.1557
7/22/2005	COOKED	2	5	LSM	27	0.145	0.141	1.1438	1.1377
7/22/2005	COOKED	2	5	MSM	27	0.134	0.129	1.1508	1.1358
7/22/2005	COOKED	2	5	HSM	27	0.138	0.138	1.1526	1.1545
9/18/2005	RAW	3	0	CON	10	0.053	0.054	1.1525	1.1547
9/18/2005	RAW	3	0	BAT	10	0.056	0.056	1.1529	1.1554
9/18/2005	RAW	3	0	ROS	10	0.091	0.089	1.1467	1.1510

Table B-17. Continued

Date	CON	Rep	Day	Trt	Fat	I-B1	I-B2	DWt1	DWt2
9/18/2005	RAW	3	0	LSM	10	0.098	0.098	1.1552	1.1564
9/18/2005	RAW	3	0	MSM	10	0.08	0.081	1.1564	1.1454
9/18/2005	RAW	3	0	HSM	10	0.347	0.354	1.1454	1.1372
9/18/2005	RAW	3	0	CON	27	0.052	0.049	1.1483	1.1533
9/18/2005	RAW	3	0	BAT	27	0.054	0.056	1.1543	1.1547
9/18/2005	RAW	3	0	ROS	27	0.074	0.075	1.1429	1.1559
9/18/2005	RAW	3	0	LSM	27	0.074	0.074	1.1543	1.1430
9/18/2005	RAW	3	0	MSM	27	0.071	0.074	1.1435	1.1397
9/18/2005	RAW	3	0	HSM	27	0.074	0.077	1.1527	1.1437
9/18/2005	COOKED	3	0	CON	10	0.148	0.147	1.1583	1.1582
9/18/2005	COOKED	3	0	BAT	10	0.107	0.108	1.1367	1.1571
9/18/2005	COOKED	3	0	ROS	10	0.094	0.092	1.1596	1.1450
9/18/2005	COOKED	3	0	LSM	10	0.136	0.138	1.1441	1.1568
9/18/2005	COOKED	3	0	MSM	10	0.144	0.142	1.1357	1.1562
9/18/2005	COOKED	3	0	HSM	10	0.153	0.154	1.1488	1.1458
9/18/2005	COOKED	3	0	CON	27	0.105	0.108	1.1533	1.1517
9/18/2005	COOKED	3	0	BAT	27	0.106	0.107	1.1462	1.1456
9/18/2005	COOKED	3	0	ROS	27	0.137	0.136	1.1548	1.1574
9/18/2005	COOKED	3	0	LSM	27	0.126	0.125	1.1470	1.1540
9/18/2005	COOKED	3	0	MSM	27	0.163	0.161	1.1470	1.1467
9/18/2005	COOKED	3	0	HSM	27	0.255	0.25	1.1409	1.1473
9/29/2005	COOKED	3	5	CON	10	0.164	0.16	1.1503	1.1581
9/29/2005	COOKED	3	5	BAT	10	0.112	0.114	1.1437	1.1509
9/29/2005	COOKED	3	5	ROS	10	0.141	0.141	1.1418	1.1542
9/29/2005	COOKED	3	5	LSM	10	0.111	0.11	1.1533	1.1382
9/29/2005	COOKED	3	5	MSM	10	0.149	0.15	1.1465	1.1400
9/29/2005	COOKED	3	5	HSM	10	0.141	0.141	1.1566	1.1461
9/29/2005	COOKED	3	5	CON	27	0.156	0.157	1.1591	1.1441
9/29/2005	COOKED	3	5	BAT	27	0.15	0.148	1.1432	1.1547
9/29/2005	COOKED	3	5	ROS	27	0.15	0.151	1.1562	1.1544
9/29/2005	COOKED	3	5	LSM	27	0.138	0.141	1.1401	1.1454
9/29/2005	COOKED	3	5	MSM	27	0.167	0.172	1.1586	1.1452
9/29/2005	COOKED	3	5	HSM	27	0.174	0.174	1.1562	1.1391

Table B-18. Raw non-heme iron sample weight data table of the cooked gound beef patties

Date	CON	Rep	Day	Trt	Fat	SWt1	SWt2	DWt1	DWt2
7/10/2005	RAW	1	0	CON	10	2.1443	2.5169	1.8049	1.9119
7/10/2005	RAW	1	0	BAT	10	2.0872	2.2148	1.8656	1.8605
7/10/2005	RAW	1	0	ROS	10	2.0585	2.1542	1.7319	1.7862
7/10/2005	RAW	1	0	LSM	10	2.2333	2.0202	1.7785	1.7001
7/10/2005	RAW	1	0	MSM	10	2.5614	2.3769	1.9031	1.8557
7/10/2005	RAW	1	0	HSM	10	2.2574	2.2384	1.8874	1.8746
7/10/2005	RAW	1	0	CON	27	2.1190	2.0183	2.0670	2.0368
7/10/2005	RAW	1	0	BAT	27	2.1061	2.3369	2.0378	2.1309
7/10/2005	RAW	1	0	ROS	27	2.1396	2.2269	2.1213	2.1166
7/10/2005	RAW	1	0	LSM	27	2.1746	2.1558	2.1334	2.1403
7/10/2005	RAW	1	0	MSM	27	2.2663	2.0621	2.1018	2.0472
7/10/2005	RAW	1	0	HSM	27	2.1333	2.3176	2.0977	2.1925
7/10/2005	COOKED	1	0	CON	10	1.0303	1.1759	1.5270	1.5774
7/10/2005	COOKED	1	0	BAT	10	1.0902	1.1872	1.5673	1.6197
7/10/2005	COOKED	1	0	ROS	10	1.0935	1.2570	1.5745	1.6331
7/10/2005	COOKED	1	0	LSM	10	1.1972	1.1515	1.6502	1.6141
7/10/2005	COOKED	1	0	MSM	10	1.0509	1.0114	1.5445	1.5291
7/10/2005	COOKED	1	0	HSM	10	1.2160	1.0159	1.6395	1.5577
7/10/2005	COOKED	1	0	CON	27	1.3111	1.2251	1.7294	1.6872
7/10/2005	COOKED	1	0	BAT	27	1.0863	1.1872	1.6773	1.7382
7/10/2005	COOKED	1	0	ROS	27	1.1040	1.1491	1.6790	1.6854
7/10/2005	COOKED	1	0	LSM	27	1.2307	1.1109	1.7128	1.6805
7/10/2005	COOKED	1	0	MSM	27	1.3993	1.0876	1.7986	1.6435
7/10/2005	COOKED	1	0	HSM	27	1.3287	1.1785	1.7827	1.7182
7/15/2005	COOKED	1	5	CON	10	1.2309	1.4753	1.6320	1.7240
7/15/2005	COOKED	1	5	BAT	10	1.1422	1.3813	1.5599	1.6705
7/15/2005	COOKED	1	5	ROS	10	1.2502	1.2702	1.6656	1.6824
7/15/2005	COOKED	1	5	LSM	10	1.2511	1.3340	1.6513	1.6811
7/15/2005	COOKED	1	5	MSM	10	1.1883	1.3137	1.6355	1.6839
7/15/2005	COOKED	1	5	HSM	10	1.2075	1.2678	1.6226	1.6359
7/15/2005	COOKED	1	5	CON	27	1.2694	1.2108	1.7636	1.7268
7/15/2005	COOKED	1	5	BAT	27	1.1735	1.4925	1.6801	1.8460
7/15/2005	COOKED	1	5	ROS	27	2.1363	1.5776	2.1403	1.8079
7/15/2005	COOKED	1	5	LSM	27	1.3792	1.3548	1.8274	1.8079
7/15/2005	COOKED	1	5	MSM	27	1.493	1.3243	1.8560	1.7804
7/15/2005	COOKED	1	5	HSM	27	1.2881	1.1665	1.7573	1.6878
7/17/2005	RAW	2	0	CON	10	1.1195	1.0663	1.4624	1.4493

Table B-18. Continued

Date	CON	Rep	Day	Trt	Fat	SWt1	SWt2	DWt1	DWt2
7/17/2005	RAW	2	0	BAT	10	1.3036	1.0728	1.5163	1.4486
7/17/2005	RAW	2	0	ROS	10	1.1663	1.1466	1.4977	1.4799
7/17/2005	RAW	2	0	LSM	10	1.0570	1.0139	1.4823	1.4651
7/17/2005	RAW	2	0	MSM	10	1.1852	1.1187	1.4912	1.4652
7/17/2005	RAW	2	0	HSM	10	1.2432	1.2612	1.4924	1.5143
7/17/2005	RAW	2	0	CON	27	1.1938	1.2144	1.6556	1.6586
7/17/2005	RAW	2	0	BAT	27	1.3450	1.0840	1.7288	1.6098
7/17/2005	RAW	2	0	ROS	27	1.0086	1.2542	1.5897	1.6808
7/17/2005	RAW	2	0	LSM	27	1.0122	1.3012	1.5903	1.7107
7/17/2005	RAW	2	0	MSM	27	1.2295	1.1340	1.6911	1.6437
7/17/2005	RAW	2	0	HSM	27	1.1474	1.2225	1.648	1.6881
7/17/2005	COOKED	2	0	CON	10	1.1867	1.2625	1.5658	1.6009
7/17/2005	COOKED	2	0	BAT	10	1.1726	1.3406	1.5632	1.6126
7/17/2005	COOKED	2	0	ROS	10	1.1899	1.0951	1.5787	1.5362
7/17/2005	COOKED	2	0	LSM	10	1.2065	1.2345	1.6256	1.6495
7/17/2005	COOKED	2	0	MSM	10	1.2554	1.0364	1.6010	1.5311
7/17/2005	COOKED	2	0	HSM	10	1.1573	1.2260	1.5619	1.5965
7/17/2005	COOKED	2	0	CON	27	1.2779	1.3052	1.7137	1.7437
7/17/2005	COOKED	2	0	BAT	27	1.0311	1.0789	1.6165	1.6351
7/17/2005	COOKED	2	0	ROS	27	1.1335	1.1284	1.7006	1.6798
7/17/2005	COOKED	2	0	LSM	27	1.4392	1.4083	1.8196	1.8062
7/17/2005	COOKED	2	0	MSM	27	1.0321	1.4909	1.6547	1.8854
7/17/2005	COOKED	2	0	HSM	27	1.3341	1.0864	1.7730	1.6587
7/22/2005	COOKED	2	5	CON	10	1.2486	1.1109	1.5653	1.5398
7/22/2005	COOKED	2	5	BAT	10	1.0470	1.2051	1.5162	1.5612
7/22/2005	COOKED	2	5	ROS	10	1.1027	1.1855	1.5475	1.5570
7/22/2005	COOKED	2	5	LSM	10	1.1261	1.1492	1.5816	1.6034
7/22/2005	COOKED	2	5	MSM	10	1.2797	1.2847	1.6268	1.6298
7/22/2005	COOKED	2	5	HSM	10	1.2267	1.3263	1.5777	1.6125
7/22/2005	COOKED	2	5	CON	27	1.3796	1.2221	1.7967	1.7241
7/22/2005	COOKED	2	5	BAT	27	1.1571	1.2580	1.6958	1.7553
7/22/2005	COOKED	2	5	ROS	27	1.1281	1.2600	1.6911	1.7483
7/22/2005	COOKED	2	5	LSM	27	1.0325	1.3170	1.6587	1.7943
7/22/2005	COOKED	2	5	MSM	27	1.3052	1.3077	1.7845	1.7744
7/22/2005	COOKED	2	5	HSM	27	1.3246	1.1980	1.7971	1.7210
9/18/2005	RAW	3	0	CON	10	1.0568	1.3556	1.4798	1.5399
9/18/2005	RAW	3	0	BAT	10	1.1164	1.1708	1.4686	1.4968
9/18/2005	RAW	3	0	ROS	10	1.5420	1.4058	1.5499	1.5410

Table B-18. Continued

Date	CON	Rep	Day	Trt	Fat	SWt1	SWt2	DWt1	DWt2
9/18/2005	RAW	3	0	LSM	10	1.4456	1.1119	1.5483	1.4460
9/18/2005	RAW	3	0	MSM	10	1.1880	1.2057	1.4905	1.4641
9/18/2005	RAW	3	0	HSM	10	1.2152	1.0517	1.4983	1.4060
9/18/2005	RAW	3	0	CON	27	1.2932	1.1751	1.6732	1.6405
9/18/2005	RAW	3	0	BAT	27	1.0924	1.2279	1.6065	1.6733
9/18/2005	RAW	3	0	ROS	27	1.2140	1.6894	1.6344	1.8295
9/18/2005	RAW	3	0	LSM	27	1.1392	1.0317	1.6196	1.5712
9/18/2005	RAW	3	0	MSM	27	1.4288	1.1586	1.7325	1.6181
9/18/2005	RAW	3	0	HSM	27	1.0716	1.2268	1.6027	1.6283
9/18/2005	COOKED	3	0	CON	10	1.4532	1.1170	1.6801	.
9/18/2005	COOKED	3	0	BAT	10	1.0270	1.0231	1.5038	1.5252
9/18/2005	COOKED	3	0	ROS	10	1.1897	1.1572	1.5626	1.5379
9/18/2005	COOKED	3	0	LSM	10	1.0944	1.0379	1.5548	1.5499
9/18/2005	COOKED	3	0	MSM	10	1.0992	1.1081	1.5677	1.5942
9/18/2005	COOKED	3	0	HSM	10	1.0145	1.1942	1.5094	1.5654
9/18/2005	COOKED	3	0	CON	27	1.2092	1.1358	1.6815	1.6514
9/18/2005	COOKED	3	0	BAT	27	1.2540	1.2703	1.7238	1.7541
9/18/2005	COOKED	3	0	ROS	27	1.3465	1.2158	1.7845	1.7359
9/18/2005	COOKED	3	0	LSM	27	1.0122	1.3611	1.6014	1.7898
9/18/2005	COOKED	3	0	MSM	27	1.2491	1.2667	1.7471	1.7423
9/18/2005	COOKED	3	0	HSM	27	1.0158	1.2034	1.6689	1.7569
9/29/2005	COOKED	3	5	CON	10	1.1492	1.1122	1.5267	1.5162
9/29/2005	COOKED	3	5	BAT	10	1.2399	1.2320	1.5673	1.5697
9/29/2005	COOKED	3	5	ROS	10	1.1082	1.1452	1.5352	1.5620
9/29/2005	COOKED	3	5	LSM	10	1.1989	1.1167	1.5606	1.5205
9/29/2005	COOKED	3	5	MSM	10	1.0499	1.0941	1.5360	1.5440
9/29/2005	COOKED	3	5	HSM	10	1.0877	1.1591	1.5176	1.5366
9/29/2005	COOKED	3	5	CON	27	1.2114	1.1184	1.7139	1.6806
9/29/2005	COOKED	3	5	BAT	27	1.1703	1.2070	1.7082	1.7392
9/29/2005	COOKED	3	5	ROS	27	1.0938	1.0038	1.6564	1.5989
9/29/2005	COOKED	3	5	LSM	27	1.2280	1.0446	1.6914	1.6097
9/29/2005	COOKED	3	5	MSM	27	1.0870	1.1898	1.6770	1.7114
9/29/2005	COOKED	3	5	HSM	27	1.1616	1.1229	1.6932	1.6707

VITA

Dae Keun Shin

Dae Keun Shin was born in Suwon, Korea to Mr. and Mrs. Shin. He attended Shin-heung High School and graduated with honors in 1990. In Feburary 1996, he received his Bachelor of Science degree in animal science from Jeonbuk National University. In addition, Dae Keun entered graduate school at Seoul National University to obtain his Master of Science degree in animal science under the direction of Dr. Mooha Lee. Following the completion of his Master of Science, he also entered graduate school at Texas A&M University to receive his Master of Science degree in food science technology under the direction of Dr. Rhonda K. Miller. After his master degree, Dae Keun will pursue a Ph.D. under the direction of Dr. Marcos Sanchez with the Department of Poultry Science, Texas A&M University, College Station, TX 77843-2472.